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ABSTRACT

This guide provides teachers with materials, information, and classroom activities to enhance any drinking water curriculum. Students can use the activity sheets to further lessons and stimulate thought. Parents can use the guide to develop science projects that will provoke thought, encourage research, and provide a scientific approach to answering questions. Water tips, facts, myths, and trivia to further awareness of drinking water issues are included. The packet is divided into six sections: a table of contents, activities for grades K-3, activities for grades 4-7, activities for grades 8-12, general information, and science projects. (SAH)

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United States
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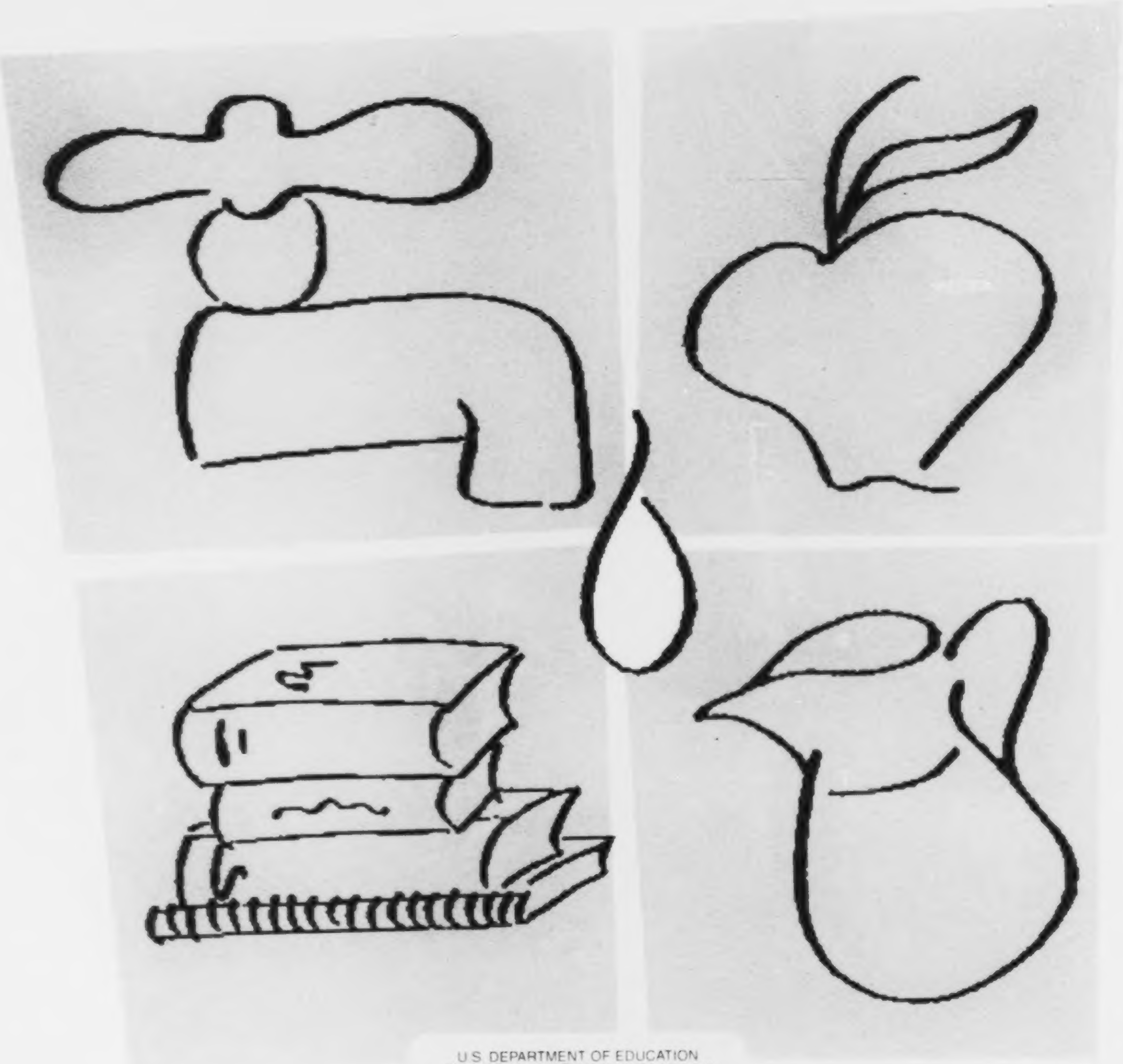
March 1999

EPA

Drinking Water Activities for Students, Teachers, and Parents

ED 449 999



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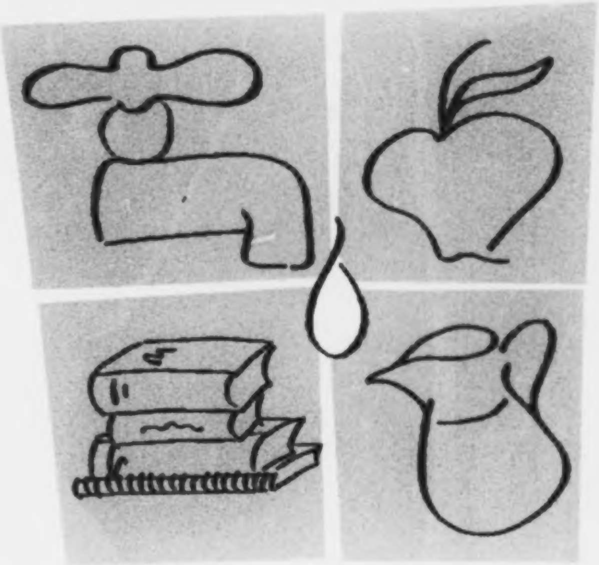

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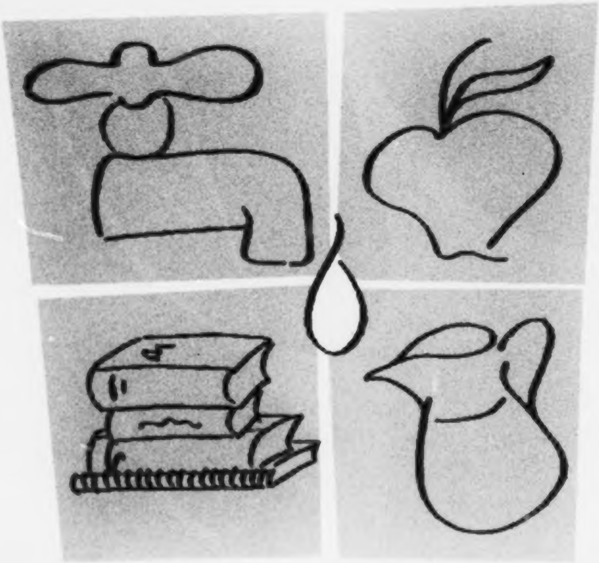
Introduction



Introduction

Over the past several years, the U.S. Environmental Protection Agency (EPA) has participated as a member of the National Drinking Water Week Alliance. This group has been responsible for heightening the awareness of drinking water issues during a week long observance, which always falls on the first full week of May. Each year the Alliance has included educational materials for teachers and students to use in the classroom. All are fun activities, but carry a strong message that water needs to be cared for, protected and nurtured, thus the phrase "blue thumb" was born. As the green thumb symbolizes the care of the earth, blue thumb reflects a like commitment to water. Throughout the material that follows, you will see a variety of themes and slogans, but the same idea will emerge: drinking water must be protected. This means we must all support our public water suppliers as they continue to comply with new regulations that will provide a greater degree of public health.

As citizens, we have an integral part in drinking water quality. With the passage of the 1996 Amendments to the Safe Drinking Water Act, Congress has provided several public right to know provisions that allow citizens to help shape the decisions made about their drinking water. For the first time, users of public water supplies will receive a Consumer Confidence Report, a yearly accounting of the water they drink. You can find out more about what you can do by visiting our website: http://www.epa.gov/safewater/ or by calling the Safe Drinking Water Hotline at 1-800-426-4791.

EPA is only one of several organizations that have made this material available to you to further your knowledge of drinking water issues. Current Alliance Partners include: the U.S. Department of Agriculture's Cooperative State Research Education and Extension Service; the National Drinking Water Clearing House; the American Water Works Association; and Environment Canada. Contributing partners include: The Ground Water Foundation; Groundwater Trust; WaterCan; the National Association of Water Companies; the Association of Metropolitan Water Agencies; the Association of State Drinking Water Administrators; the League of Women Voters; National Geographic; the Water Education Foundation; and the American Library Association.

Intended Use of Materials

Teachers: Materials will provide additional information and classroom activities to enhance any drinking water curriculum you teach.

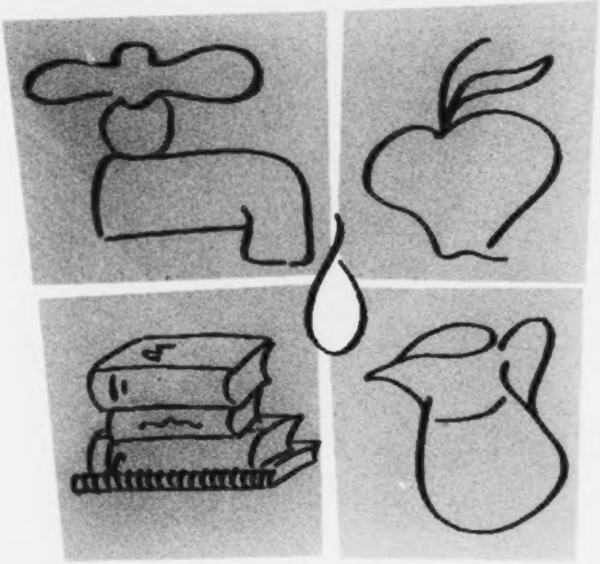
Students: Easy to duplicate student activity sheets to further the message and stimulate thought.

Parents: As that time of year approaches, students, teachers and parents all share in a responsibility to develop a science project that will provoke thought, encourage research, and provide a scientific approach to answering a question. A science demonstration projects section has been added with ideas to build on or use as presented.

General Information: All users of these materials will find water tips, facts, myths, and trivia to further their awareness of drinking water issues across the Nation.

We hope that you will use these materials to educate yourself and those you come in contact with, not only in a classroom situation, but anywhere the message should be heard.

Drinking Water Activities: K-3

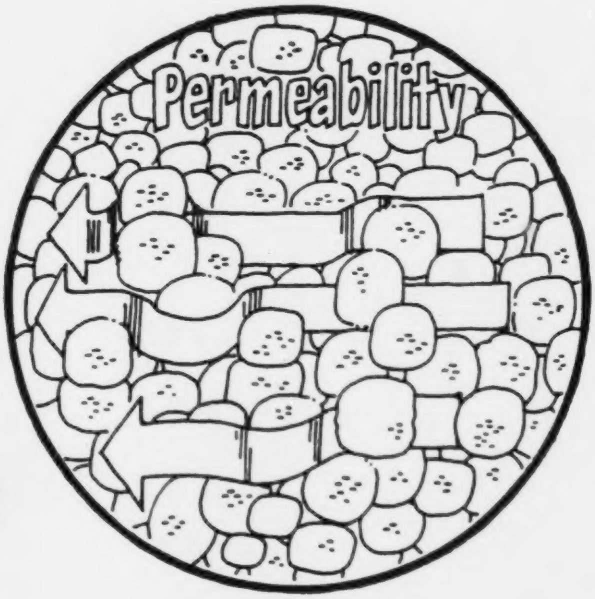


Ground water is water underground in saturated zones beneath the land surface. Contrary to popula belief, ground water does not form underground "rivers." It fills the pores and fractures in undergroun materials such as sand, gravel, and other rock. If ground water flows from rock materials or can be remove by pumping from the saturated rock materials in useful amounts, the rock materials are called aquifers Ground water moves slowly, typically at rates of 7 to 60 centimeters per day in an aquifer. As a result, wate could remain in an aquifer for hundreds or thousands of years. Ground water is the source of about 4 percent of water used for public supplies and about 38 percent of water used for agriculture in the Unite States.

One of the largest aquifers in the United States is the High Plains Aquifer. The aquifer is approximatel the size of California and is located under parts of South Dakota, Wyoming, Kansas, Nebraska, Colorad New Mexico, Oklahoma, and Texas. The High Plains Aquifer contains an estimated 4 quadrillion liters (with 15 zeros after it) of water.

DEFINITIONS

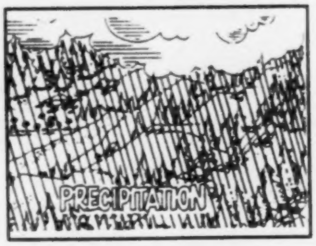
Aquifer	- An underground body of porous sand, gravel, or fractured rock filled with water and capable of supplying useful quantities of water to a well or spring.
Crystalline Rock	- Igneous or metamorphic rock consisting of relatively large mineral grains.
Freshwater	- Water that contains less than 1,000 milligrams per liter of dissolved solids.
Ground Water	- Water beneath the land surface in the saturated zone.
Ground-Water Discharge	- The flow or pumping of water from an aquifer.
Ground-Water Recharge	- The addition of water to an aquifer.
Infiltration	- Movement of water from the land surface into the soil.
Permeability	- The capacity of porous rock for transmitting water.
Public Supplies	- Water supplied for domestic, commercial, thermoelectric power, industrial, and other public uses.
Saturated Zone	- Zone below the land surface where all the pores or fractures are filled with water.
Surface Water	- Water on the Earth's surface.
Unsaturated Zone	- The zone immediately below the land surface where the pores or fractures contain both water and air.
Water Table	- The top of the water surface in the saturated zone of an unconfined aquifer.



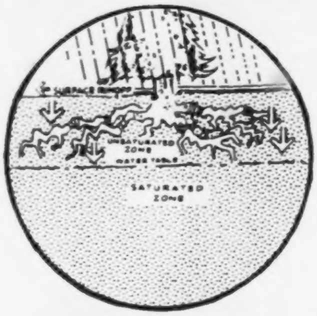
Permeability

For water to move in an aquifer, the pores between rock materials and fractures in rock must be connected. If there is a good connection among pore spaces and fractures, water can move freely and we say that the rock is permeable. The capacity of rock material to transmit water is called permeability. Water moves through different materials at different rates — faster through gravel, slower through sand, and much slower through clay. Therefore, gravel is more permeable than sand, which is more permeable than clay.

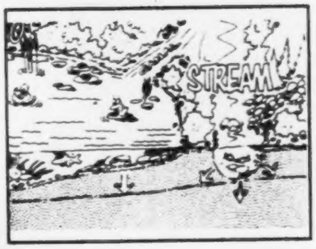
Recharge Areas



Recharge is the addition of water to the ground-water system. The recharge of freshwater begins as precipitation. Precipitation occurs in several forms, including rain, snow, and hail, but only rain is displayed on the poster. Some of the rain infiltrates into the soil. If the rate of the rainfall exceeds the rate of infiltration, surface water will flow over the land surface to surface-water bodies such as rivers and streams.

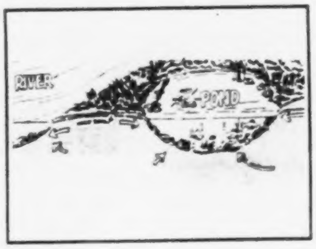


Water can infiltrate faster from the land surface into sandy soils than silty or clay soils. Water infiltrates into the soil and the unsaturated zone. The unsaturated zone occurs immediately below the land surface and contains both water and air in the pores and fractures in the rock materials. Water moves, or percolates, down through the unsaturated zone to the saturated zone. The saturated zone is where all the pores or fractures in rock materials are filled with water. The top of the saturated zone is called the water table.

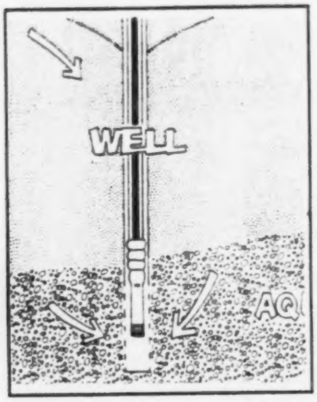


Because surface-water and ground-water systems are connected, surface water can recharge ground water. Aquifers can obtain water from such surface-water bodies as reservoirs and streams when and where the water table is lower than the surface-water body. Recharge areas usually are higher in elevation than discharge areas.

Discharge Areas



Places where ground water flows from aquifers to springs, seeps, wetlands, ponds, or streams are called ground-water discharge areas. Ground-water discharge to these natural areas occurs when the water surface of the aquifer (water table on the poster) is at or above the elevation of the discharge area (river and pond on the poster). Surface-water and ground-water systems are interconnected. The flow of most streams is sustained by ground water seeping into the stream. The water surfaces of many ponds and wetlands are an extension of the local ground-water table. Springs occur where ground water flows from an aquifer to the land surface.



Ground water can be brought to the land surface by pumping from a well. A well is an opening that has been drilled or dug into an aquifer below the water table. Water from the aquifer flows into this opening to replace water removed by pumping water from the well. The water table slopes from areas of recharge to discharge areas like rivers, ponds, wells, and springs.

Ground-Water Movement

Introduction

Ground water must be able to move through underground materials at rates fast enough to supply useful amounts of water to wells or springs in order for those materials to be classified as an aquifer. For water to move in an aquifer, some of the pores and fractures must be connected to each other. Water moves through different materials at different rates, faster through gravel, slower through sand, and even slower through clay. Gravels and sands are possible aquifers; clays usually are not aquifers. The following activity demonstrates how different sizes of rock materials that make up an aquifer affect water movement.

Objectives--Students will:

1. Identify several sources of rock materials that make up an aquifer.
2. Discuss how water moves through gravel, sand, and clay.

Materials

1. At least 10 students.
2. Large area to conduct activity.

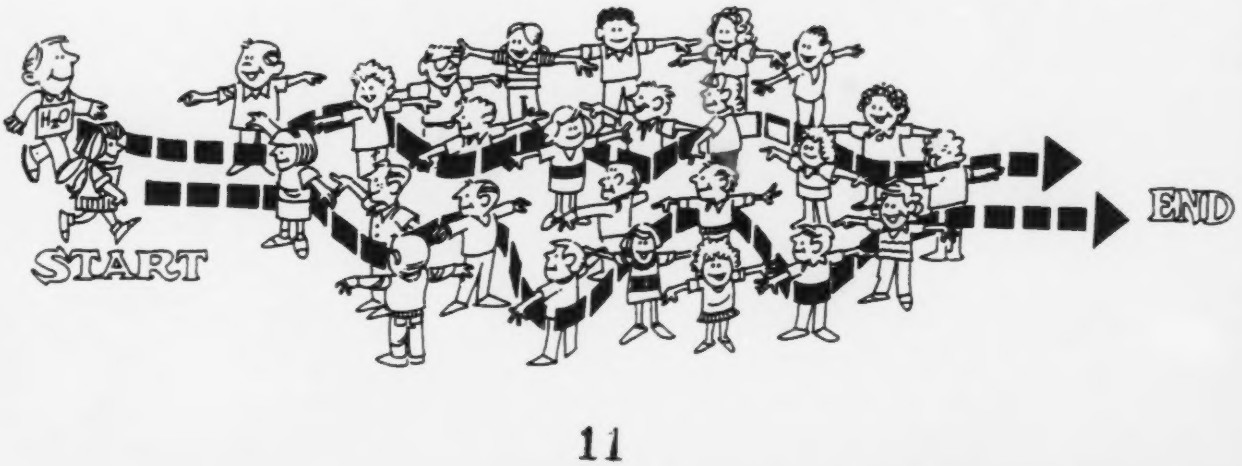
Teacher Preparation

This activity can be conducted in the classroom, gymnasium, or outside the school building. If conducted in the classroom, move all furniture to allow for sufficient room for the movement of students. This is a three-part demonstration that may create some excitement.

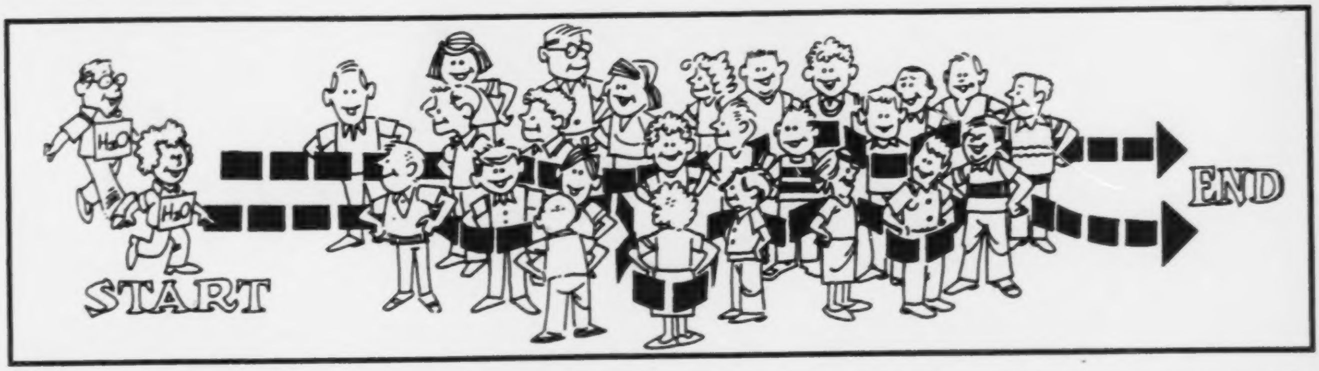
Procedures

Select two or three students to be molecules of water. The remaining students will be rock materials.

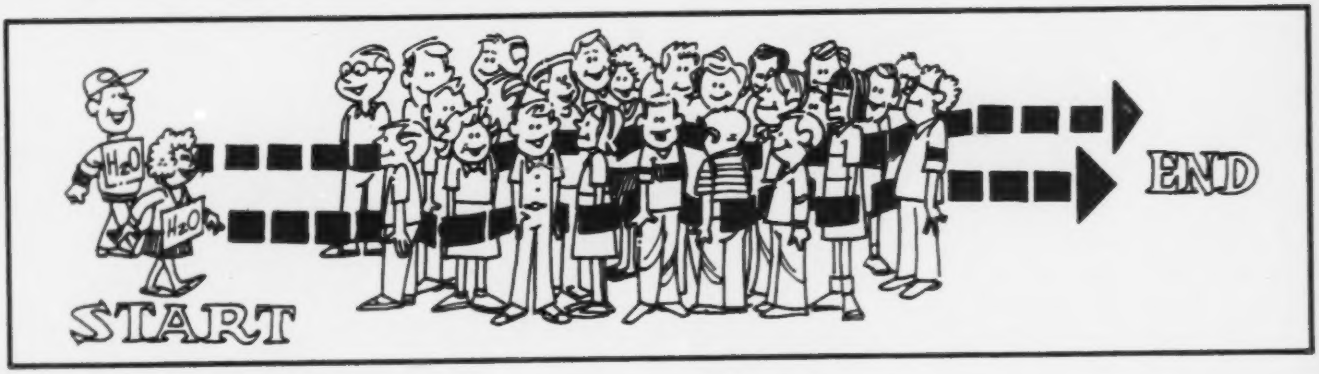
1. **Activity One:** Water movement through gravel. The students represent gravel by holding arms outstretched, leaving a 15- to 30- centimeter (cm) space between their outstretched arms. Locate these students in the center of the activity area. The students representing water molecules are to start on one side of their "gravel" classmates and move through them, exiting on the other side. The water molecules will move easily through the gravel.



2. **Activity Two:** Water movement through sand. The students represent sand by extending arms, bending them at the elbows and touching their waists with their fingers. Locate these students in the center of the activity area, spacing them approximately 15 cm apart. Once again, have the water molecules slowly make their way through their "sand" classmates. The water molecules will experience some difficulty, but should still reach the other side.



3. **Activity Three:** Water movement through clay. Students become clay particles by placing their arms straight down the sides of their bodies and standing approximately 10 cm apart. Locate these students in the center of the activity area. It will be a formidable task for water molecules to move through the clay. Without being rough, the water molecules should slowly make their way through the clay. The water molecules may not be able to move through the clay at all.



Interpretive Questions

1. Which one of the materials — gravel, sand, or clay — was the easiest for the water molecules to move through? (Answer: Gravel, then sand, then clay.) Why? (Answer: Because there are larger spaces between the gravel particles.)
2. If there were three rock units, one of gravel, one of sand, and one of clay, all containing the same quantity of water, in which would you drill a well? (Answer: Gravel. Water moves easier through gravel than sand or clay.)

Extension

Obtain 250 milliliters (mL) of sand, 250 mL of pea-size gravel, 250 mL of clay, and three large funnels (top diameter approximately 12 cm). Force a piece of cheesecloth into the top of the spout of each funnel. This will prevent material from going through the funnel spout. Put each funnel into separate clear containers so that the spout of the funnel is at least 5 cm above the bottom of the container. Pour the sand into the first funnel, pea-size gravel into the second funnel, and the clay into the third funnel. Pour equal amounts of water (approximately 200 mL) onto the materials contained in the funnels. Select three students to pour the water, creating a permeability race. Time how long it takes the water to flow through the materials. Record on a data sheet. Which material did the water flow through the fastest? Why?

This activity was adapted from "Get the Ground Water Picture," National Project WET.

Youth Activity

How People Get Their Water

Reservoirs: "Holding Tanks" for Drinking Water

Let your students **"Ride the Water Cycle"** with the following activity. It will help them understand the role of reservoirs in maintaining a reliable supply of drinking water.

Materials Needed:
- Plastic Box
- Spray bottle
- Pebbles
- Soil
- Sand
- Leaves

Objective: To illustrate how a reservoir works

Target Audience: Primary: (K-6)

Teacher's Notes:

Water moves in a continuous cycle between the air, ground, and plants and animals. Most water does not naturally exist in a pure form or in a form that is safe for people to drink. That is why water must be cleaned before we drink it. Water utilities provide such treatment before water is sent through pipes to homes in the community.

The demand for water varies. The availability of water also varies in different areas of the world. To meet those varying needs, water utilities may store extra water in places known as reservoirs. Water is usually contained in reservoirs by a dam. Reservoirs help ensure that communities do not run out of water at any given time regardless of the communities' total water use.

Questions to Expand Students' Thinking:

Q What are some of the sources of water for a reservoir?

A Precipitation in the form of rain and snow. Other bodies of water that feed the reservoir, such as lakes and rivers.

Q How does water get into a reservoir?

A It seeps over and through the soil above the reservoir.

Q What contains or holds water in a real reservoir?

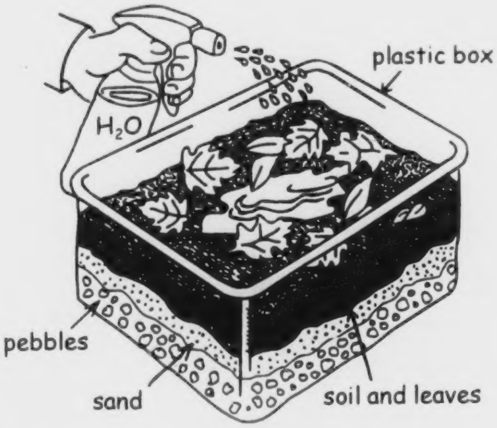
A Dams.

Q What kind of natural treatment does water receive in a reservoir?

A Natural filtration through leaves, grass and soil. Some settling also occurs in the reservoir.

Activity Directions:

1) Construct a model of a reservoir using a clean, clear plastic box. Line the bottom of the box with small pebbles and then layer sand, soil, and leaves on top.
2) Carefully spray water on the four corners of the model until the soil mixture is saturated and the water has seeped through to the open area - the reservoir.



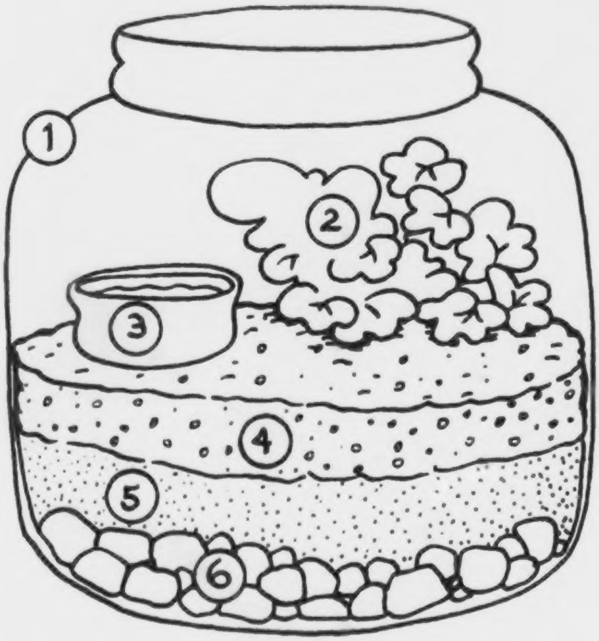
Source: U.S. Environmental Protection Agency, adopted from "Water Wizards," Massachusetts Water Resources Authority, Boston, MA, 1993

Simple Water Science

Les sciences de l'eau en un clin d'oeil.

You will need

1. jar
2. plants
3. bottle cap or shell of water
4. soil
5. sand
6. small rocks



Il te faut :

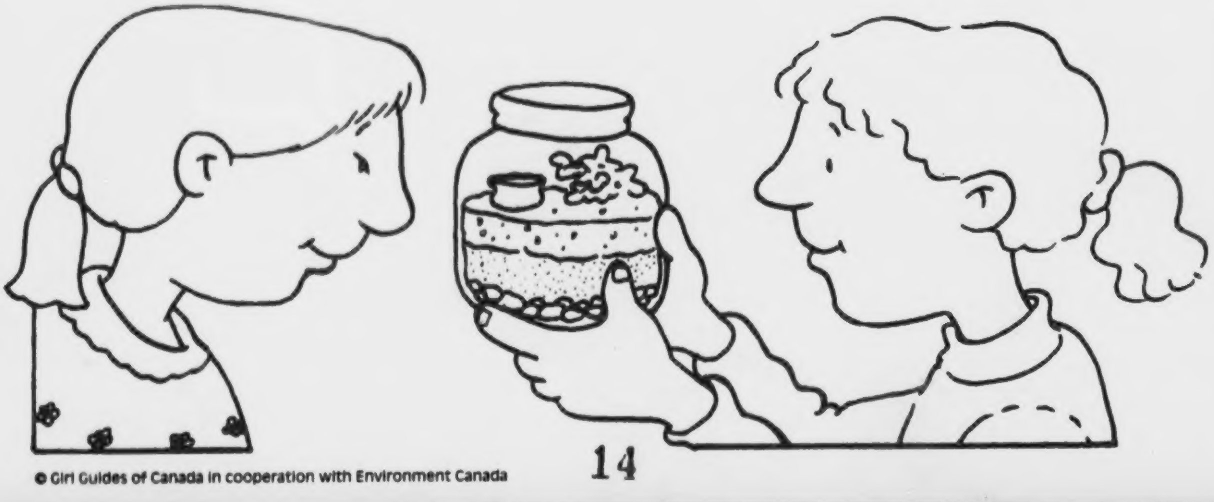
1. un pot
2. des plantes
3. une capsule de bouteille ou une coquille remplie d'eau
4. de la terre
5. du sable
6. des petites roches

Fill jar as in the picture and put the lid on. Put the jar in a sunny place and see how the water cycle works.

Remplis le pot tel qu'indiqué sur le dessin et mets le couvercle. Place le pot dans un endroit ensoleillé et observe comment le cycle de l'eau fonctionne.

BLUE THUMB

Give drinking water a hand.



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EPA ENVIRONMENTAL EDUCATION

AQUIFER IN A CUP (AQUIFER ON THE GO)

BACKGROUND: Many communities obtain their drinking water from underground sources called **aquifers**. Water suppliers or utility officials drill wells through soil and rock into aquifers to supply the public with drinking water. Homeowners who cannot obtain drinking water from a public water supply have private wells that tap the groundwater supply. Unfortunately, groundwater can become contaminated by improper use or disposal of harmful chemicals such as lawn care products and household cleaners. These chemicals can percolate down through the soil and rock into an aquifer—and eventually into the wells. Such contamination can pose a significant threat to human health. The measures that must be taken by well owners and operators to either protect or clean up contaminated aquifers are quite costly.

NOTE: This demonstration should follow a class discussion on potential sources of pollution to drinking water supplies.

OBJECTIVE: To illustrate how water is stored in an aquifer, how groundwater can become contaminated, and how this contamination ends up in a drinking water source. Ultimately, students should get a clear understanding of how careless use and disposal of harmful contaminants above the ground can potentially end up in the drinking water below the ground. This particular experiment can be done by each student at his or her work station.

MATERIALS NEEDED PER STUDENT:

1 clear plastic cup that is 2 3/4" deep x 3 1/4" wide
1 piece of modeling clay or floral clay that will allow a 2" flat pancake to be made by each student for his/her cup

White play sand that will measure 1/4" in the bottom of each student's cup
Aquarium gravel (natural color if possible) or small pebbles (approximately ½ cup per student)
(Hint: As many small rocks may have a powdery residue on them, you may wish to rinse and dry them on a clean towel prior to use. It is best if they do not make the water cloudy.)

Red food coloring
1 bucket of clean water and a **small cup** to dip water from bucket

PROCEDURE:

1. Pour 1/4" of white sand into the bottom of each cup, completely covering the bottom of the container. Pour water into the sand, wetting it completely (there should be no standing water on top of sand). Let students see how the water is absorbed in the sand, but remains around the sand particles as it is stored in the ground and ultimately in the aquifer.

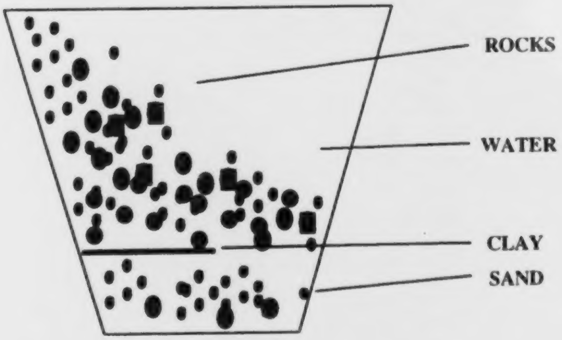
2. Have each student flatten the modeling clay (like a pancake) and cover ½ of the sand with the clay (students should press the clay to one side of the container to seal off that side). The clay represents a **"confining layer"** that keeps water from passing through it. Pour a small amount of water onto the clay. Let the students see how the water remains on top of the clay, only flowing into the sand below in areas that the clay does not cover.

3. Use the aquarium rocks to form the next layer of earth. Place the rocks over the sand and clay, covering the entire container. To one side of the cup, have students slope the rocks, forming a high hill and a valley (see illustration below). Explain to the students that these layers represent some of the many layers contained in the earth's surface. Now pour water into your aquifer until the water in the valley is even with your hill. Students will see the water stored around the rocks. Explain that these rocks are porous, allowing storage of water within the pores and openings between them. They will also notice a **"surface"** supply of water (a small lake) has formed. This will give students a view of the ground and surface water supplies, both of which can be used for drinking water purposes.

4. Put a few drops of the food coloring on top of the rock hill as close to the inside wall of the cup as possible. Explain to the students that people often use old wells to dispose of farm chemicals, trash, and used motor oils, and that other activities above their aquifer can impact their drinking water. Students will see that the color spreads not only through the rocks but also to the surface water and into the white sand at the bottom of their cups. This is one way pollution can spread through the aquifer over time.

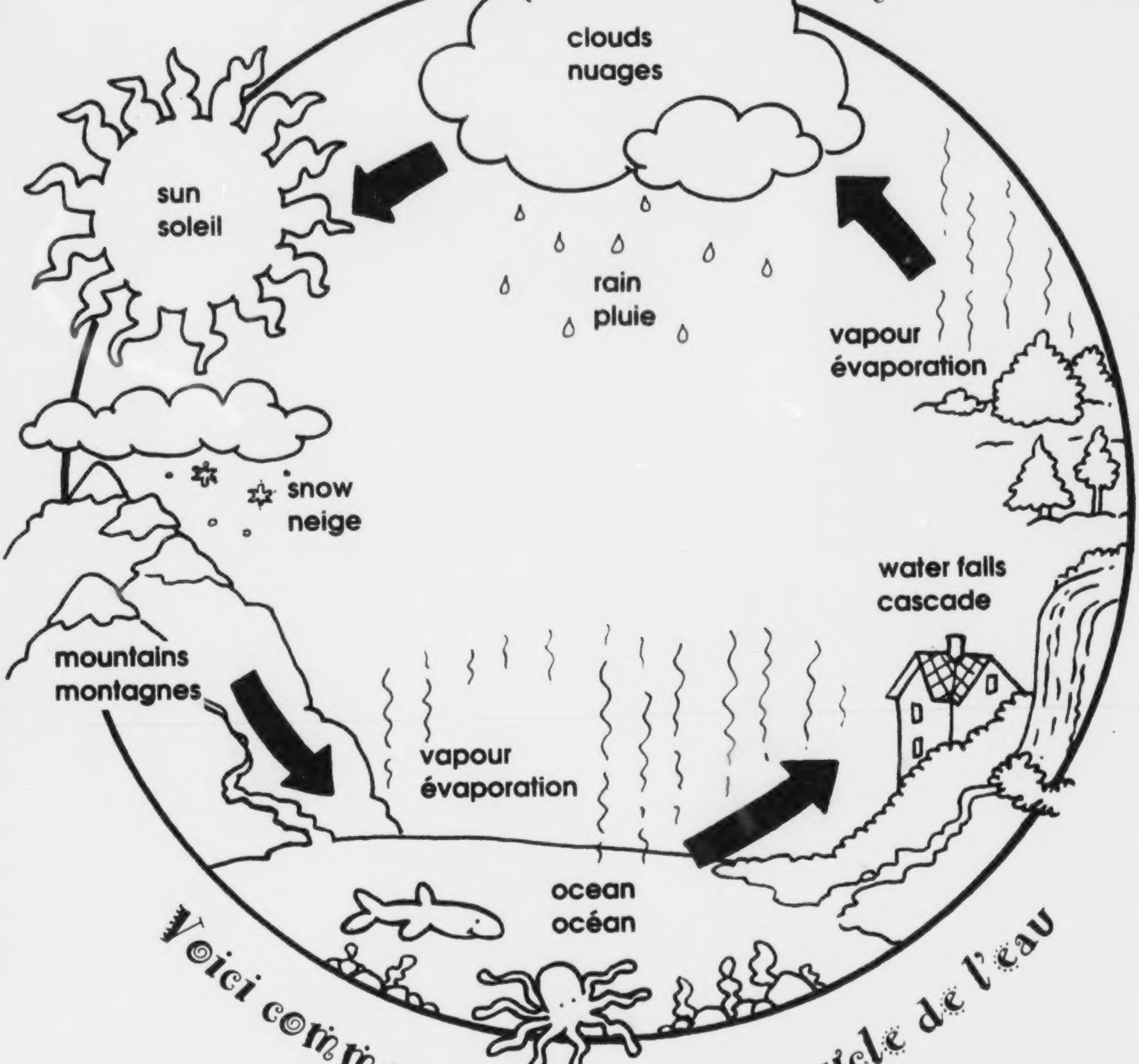
FOLLOW-UP:

Discuss with students other activities that could pollute their aquifer. Ask students to locate activities around the school or their own homes that could pollute their drinking water sources if not properly maintained. Allow students to drain off the water in their cups and carry home their containers to refill with water, showing their parents surface water, groundwater, and how pollution activity above the aquifer can affect all of the water. Students should discuss with parents what steps they can take as a household to prevent water pollution.



FOR KIDS

The Water Cycle At Work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sun
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rain
pluie
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water falls
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mountains
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ocean
océan

Voici comment fonctionne le cycle de l'eau

BLUE THUMB

Give drinking water a hand.

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Blue Thumb Coloring Fun

FOR KIDS

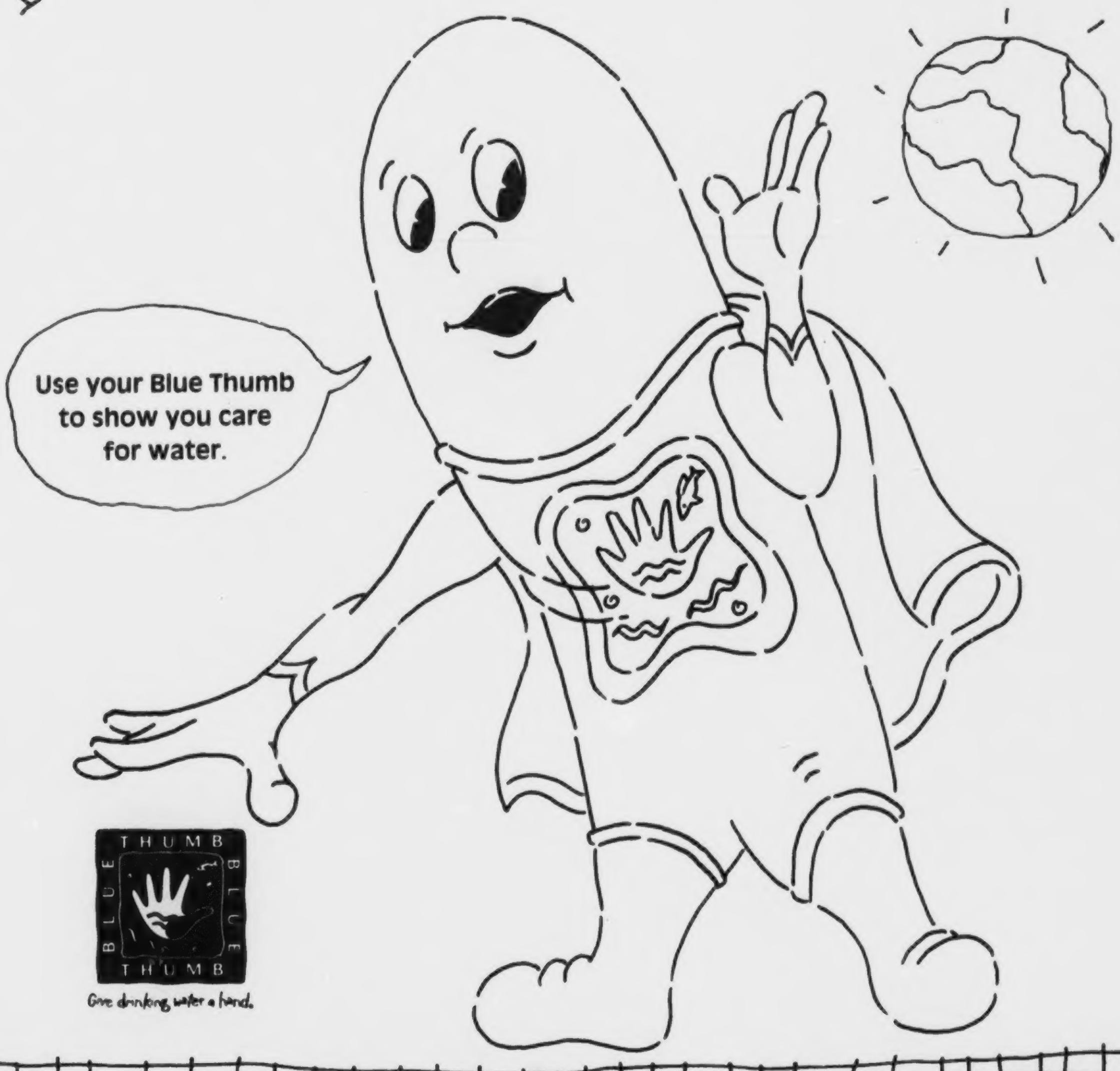
We need to use water wisely.

Turn off dripping faucets.

Fill the tub half way for a bath.

Turn off the tap when you brush your teeth.

Just use the amount you need.


Use your Blue Thumb to show you care for water.

BLUE THUMB

Give drinking water a hand.

Coloreando

FOR KIDS

Tenemos que usar bien el agua.

Arreglar los salideros de agua.

Cerrar la llave cuando se lave los dientes.

Llenar la bañadera hasta la mited solamente.

Riegue la grama, no el pavimento.

Enseñe su pulgar azul para que vean que sabe de conservar agua.

BLUE THUMB

Give drinking water a hand.

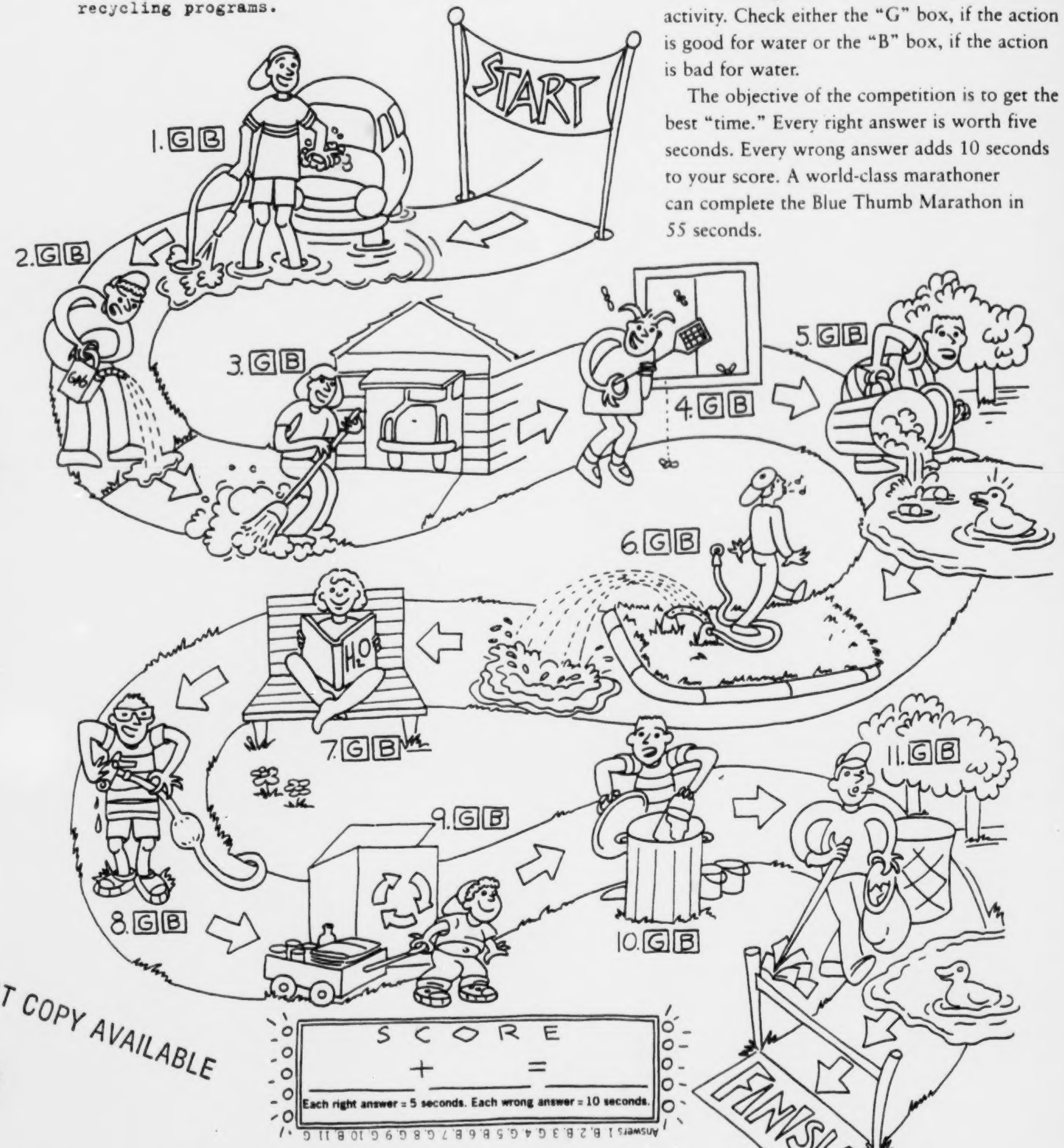
Blue Thumb
Marathon

A Blue Thumb is to water what a green thumb is to plants. Both are about having a hand in making something better.

What's good for water is conserving it — use only what you need; protecting it from pollution — don't put trash where it can get into water; and getting involved — participate in community clean-up and recycling programs.

The Blue Thumb Marathon challenges you to decide whether certain actions are good or bad for water. Begin at "Start" and stop at each activity. Check either the "G" box, if the action is good for water or the "B" box, if the action is bad for water.

The objective of the competition is to get the best "time." Every right answer is worth five seconds. Every wrong answer adds 10 seconds to your score. A world-class marathoner can complete the Blue Thumb Marathon in 55 seconds.



SCORE

______ + ______ = ______

Each right answer = 5 seconds. Each wrong answer = 10 seconds.

Answers: 1. B, 2. B, 3. G, 4. G, 5. B, 6. B, 7. G, 8. G, 9. G, 10. B, 11. G

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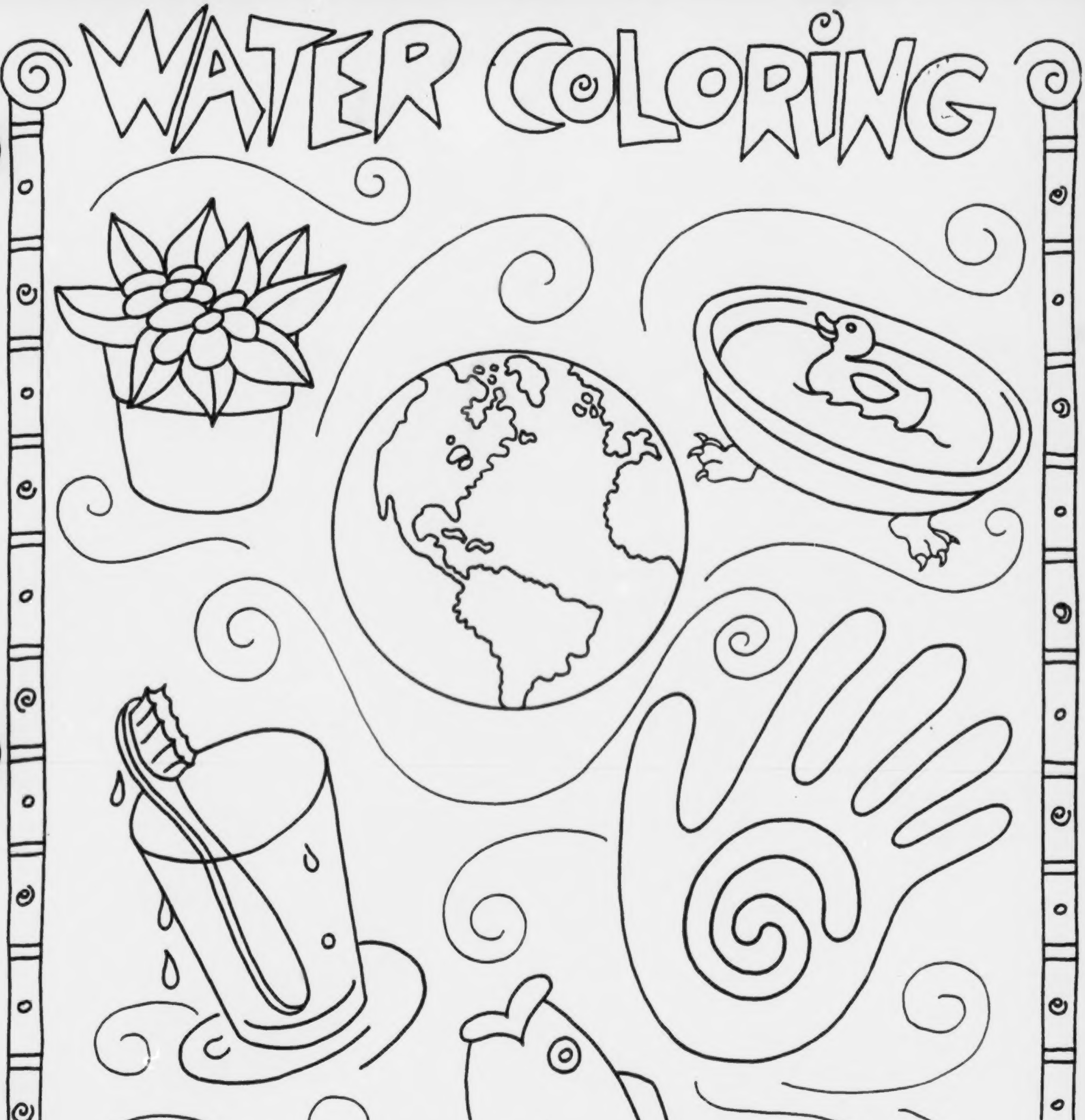
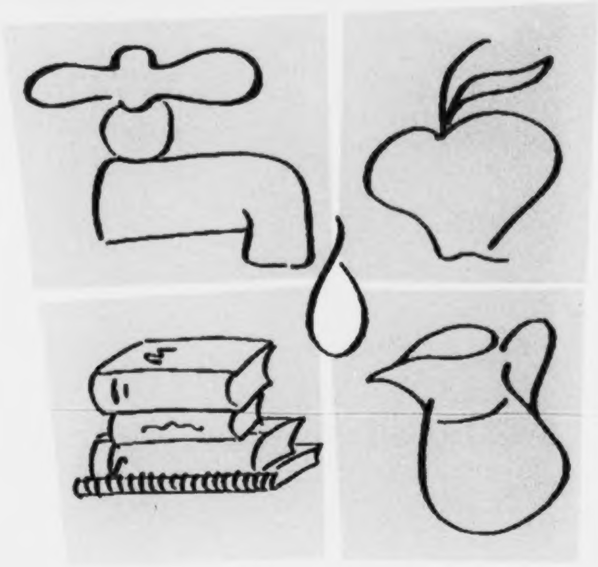
Blue Thumb Project, c/o AWWA, 6666 W. Quincy Ave., Denver, Co 80235



Exercise your Blue Thumb to create your own water colors.

Blue Thumb Project, c/o American Water Works Association, 6666 West Quincy Ave., Denver, CO 80235

Drinking Water Activities: 4-7

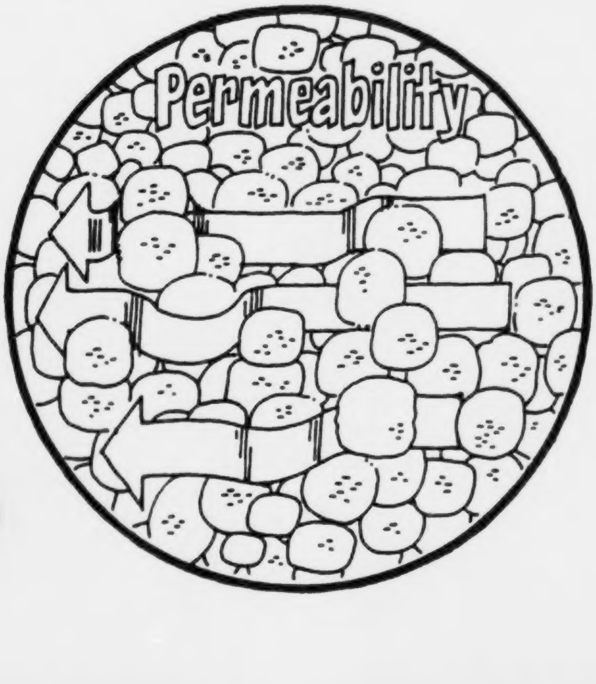


Ground water is water underground in saturated zones beneath the land surface. Contrary to popula belief, ground water does not form underground "rivers." It fills the pores and fractures in undergroun materials such as sand, gravel, and other rock. If ground water flows from rock materials or can be remove by pumping from the saturated rock materials in useful amounts, the rock materials are called aquifers Ground water moves slowly, typically at rates of 7 to 60 centimeters per day in an aquifer. As a result, wate could remain in an aquifer for hundreds or thousands of years. Ground water is the source of about 4 percent of water used for public supplies and about 38 percent of water used for agriculture in the Unite States.

One of the largest aquifers in the United States is the High Plains Aquifer. The aquifer is approximatel the size of California and is located under parts of South Dakota, Wyoming, Kansas, Nebraska, Colorad New Mexico, Oklahoma, and Texas. The High Plains Aquifer contains an estimated 4 quadrillion liters (with 15 zeros after it) of water.

DEFINITIONS

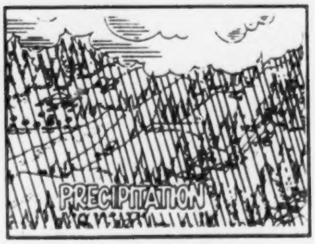
Aquifer	- An underground body of porous sand, gravel, or fractured rock filled with water and capable of supplying useful quantities of water to a well or spring.
Crystalline Rock	- Igneous or metamorphic rock consisting of relatively large mineral grains.
Freshwater	- Water that contains less than 1,000 milligrams per liter of dissolved solids.
Ground Water	- Water beneath the land surface in the saturated zone.
Ground-Water Discharge	- The flow or pumping of water from an aquifer.
Ground-Water Recharge	- The addition of water to an aquifer.
Infiltration	- Movement of water from the land surface into the soil.
Permeability	- The capacity of porous rock for transmitting water.
Public Supplies	- Water supplied for domestic, commercial, thermoelectric power, industrial, and other public uses.
Saturated Zone	- Zone below the land surface where all the pores or fractures are filled with water.
Surface Water	- Water on the Earth's surface.
Unsaturated Zone	- The zone immediately below the land surface where the pores or fractures contain both water and air.
Water Table	- The top of the water surface in the saturated zone of an unconfined aquifer.



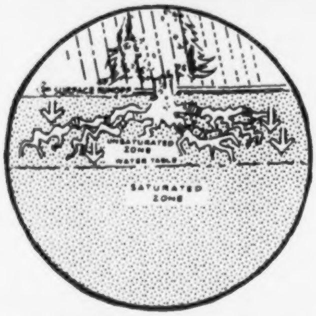
Permeability

For water to move in an aquifer, the pores between rock materials and fractures in rock must be connected. If there is a good connection among pore spaces and fractures, water can move freely and we say that the rock is permeable. The capacity of rock material to transmit water is called permeability. Water moves through different materials at different rates — faster through gravel, slower through sand, and much slower through clay. Therefore, gravel is more permeable than sand, which is more permeable than clay.

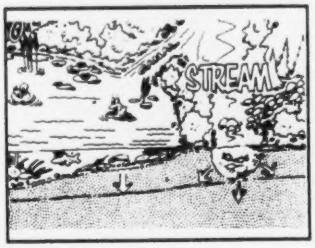
Recharge Areas



Recharge is the addition of water to the ground-water system. The recharge of freshwater begins as precipitation. Precipitation occurs in several forms, including rain, snow, and hail, but only rain is displayed on the poster. Some of the rain infiltrates into the soil. If the rate of the rainfall exceeds the rate of infiltration, surface water will flow over the land surface to surface-water bodies such as rivers and streams.

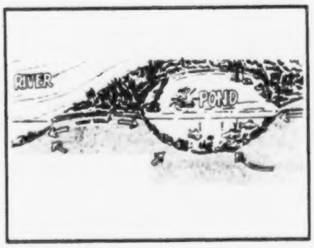


Water can infiltrate faster from the land surface into sandy soils than silty or clay soils. Water infiltrates into the soil and the unsaturated zone. The unsaturated zone occurs immediately below the land surface and contains both water and air in the pores and fractures in the rock materials. Water moves, or percolates, down through the unsaturated zone to the saturated zone. The saturated zone is where all the pores or fractures in rock materials are filled with water. The top of the saturated zone is called the water table.

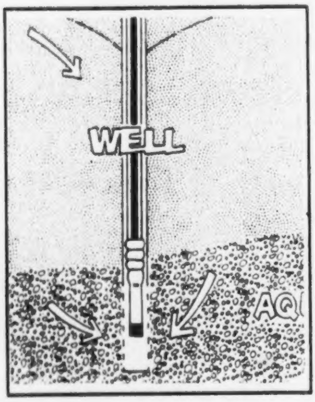


Because surface-water and ground-water systems are connected, surface water can recharge ground water. Aquifers can obtain water from such surface-water bodies as reservoirs and streams when and where the water table is lower than the surface-water body. Recharge areas usually are higher in elevation than discharge areas.

Discharge Areas



Places where ground water flows from aquifers to springs, seeps, wetlands, ponds, or streams are called ground-water discharge areas. Ground-water discharge to these natural areas occurs when the water surface of the aquifer (water table on the poster) is at or above the elevation of the discharge area (river and pond on the poster). Surface-water and ground-water systems are interconnected. The flow of most streams is sustained by ground water seeping into the stream. The water surfaces of many ponds and wetlands are an extension of the local ground-water table. Springs occur where ground water flows from an aquifer to the land surface.



Ground water can be brought to the land surface by pumping from a well. A well is an opening that has been drilled or dug into an aquifer below the water table. Water from the aquifer flows into this opening to replace water removed by pumping water from the well. The water table slopes from areas of recharge to discharge areas like rivers, ponds, wells, and springs.

Ground-Water Movement

Introduction

Ground water must be able to move through underground materials at rates fast enough to supply useful amounts of water to wells or springs in order for those materials to be classified as an aquifer. For water to move in an aquifer, some of the pores and fractures must be connected to each other. Water moves through different materials at different rates, faster through gravel, slower through sand, and even slower through clay. Gravels and sands are possible aquifers; clays usually are not aquifers. The following activity demonstrates how different sizes of rock materials that make up an aquifer affect water movement.

Objectives--Students will:

1. Identify several sources of rock materials that make up an aquifer.
2. Discuss how water moves through gravel, sand, and clay.

Materials

1. At least 10 students.
2. Large area to conduct activity.

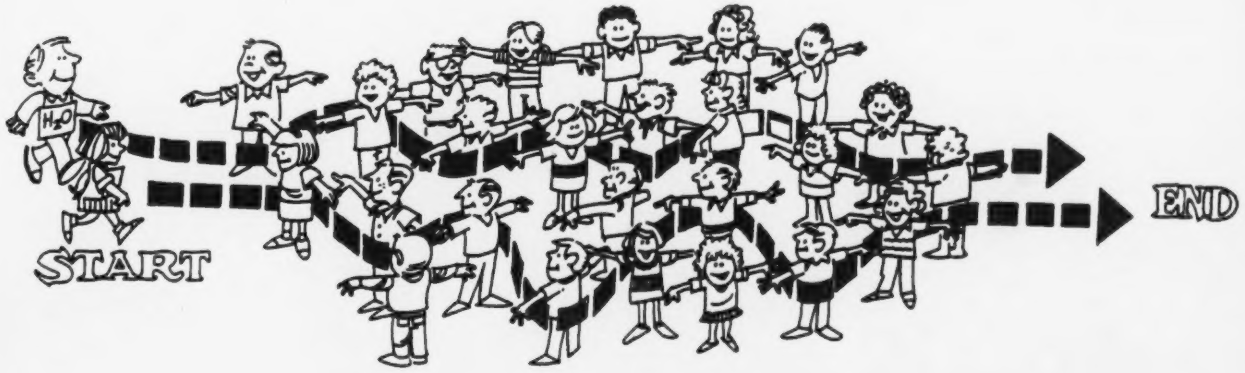
Teacher Preparation

This activity can be conducted in the classroom, gymnasium, or outside the school building. If conducted in the classroom, move all furniture to allow for sufficient room for the movement of students. This is a three-part demonstration that may create some excitement.

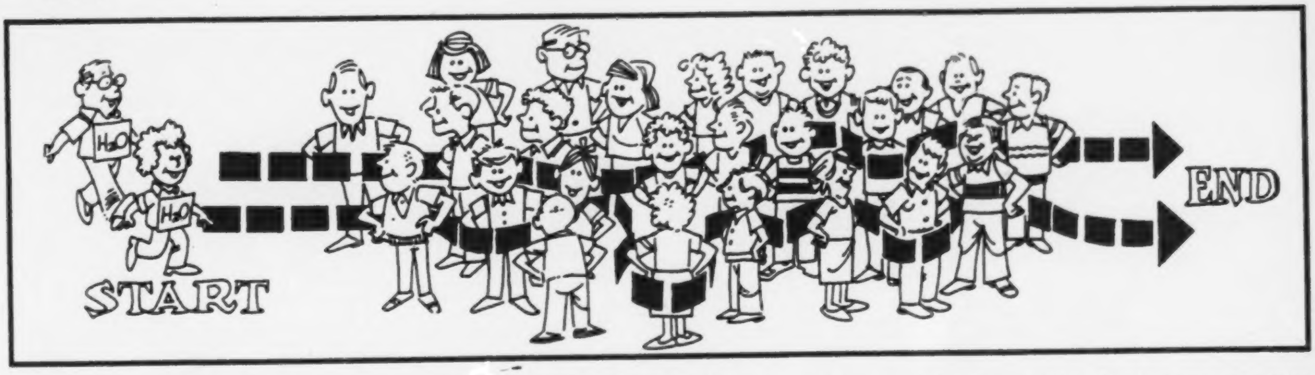
Procedures

Select two or three students to be molecules of water. The remaining students will be rock materials.

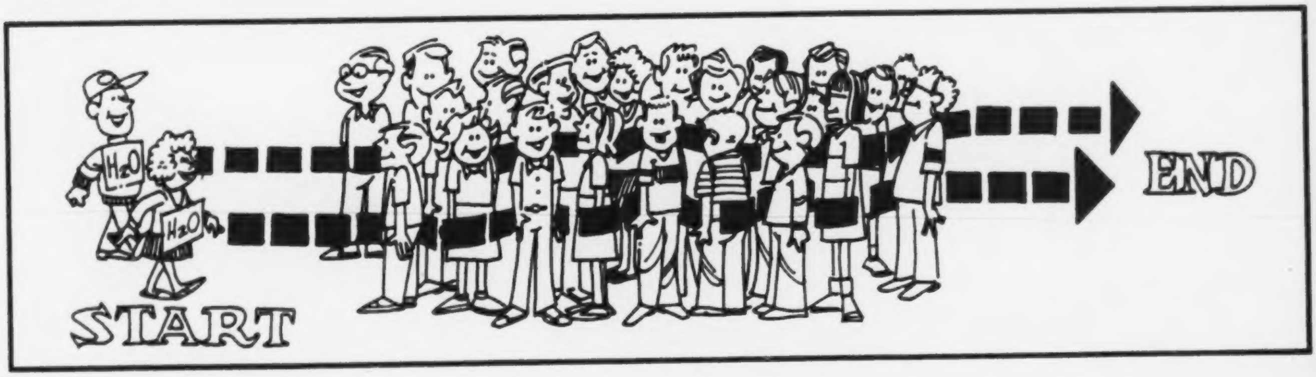
1. **Activity One:** Water movement through gravel. The students represent gravel by holding arms outstretched, leaving a 15- to 30- centimeter (cm) space between their outstretched arms. Locate these students in the center of the activity area. The students representing water molecules are to start on one side of their "gravel" classmates and move through them, exiting on the other side. The water molecules will move easily through the gravel.



2. **Activity Two:** Water movement through sand. The students represent sand by extending arms, bending them at the elbows and touching their waists with their fingers. Locate these students in the center of the activity area, spacing them approximately 15 cm apart. Once again, have the water molecules slowly make their way through their "sand" classmates. The water molecules will experience some difficulty, but should still reach the other side.



3. **Activity Three:** Water movement through clay. Students become clay particles by placing their arms straight down the sides of their bodies and standing approximately 10 cm apart. Locate these students in the center of the activity area. It will be a formidable task for water molecules to move through the clay. Without being rough, the water molecules should slowly make their way through the clay. The water molecules may not be able to move through the clay at all.



Interpretive Questions

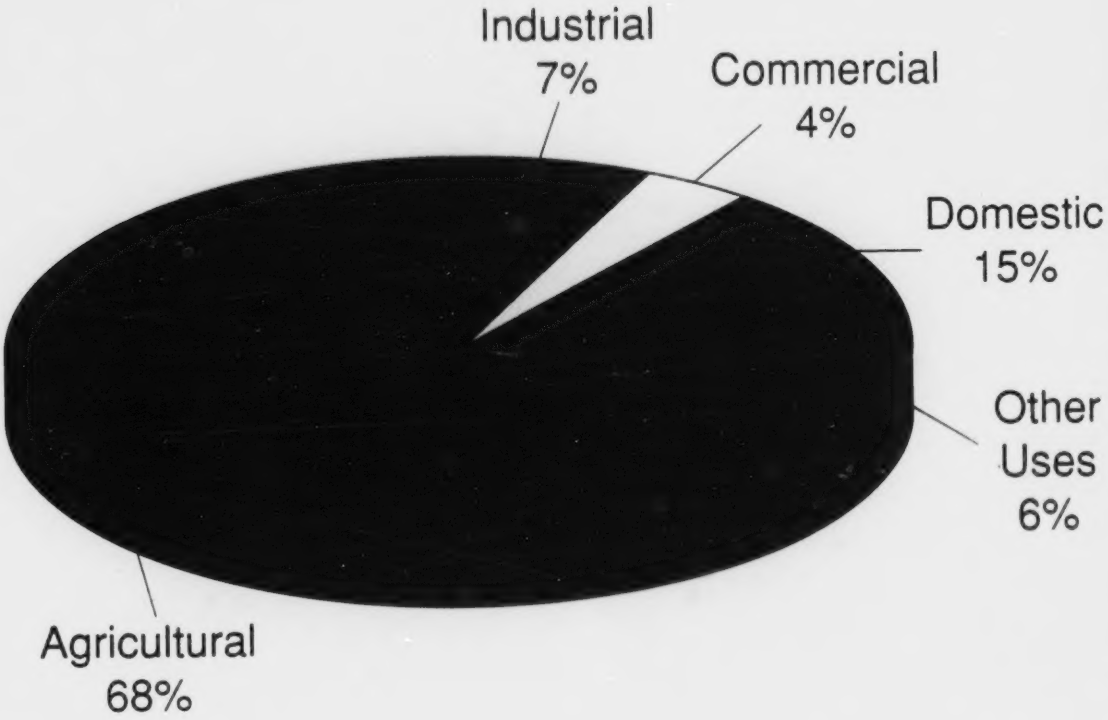
1. Which one of the materials — gravel, sand, or clay — was the easiest for the water molecules to move through? (Answer: Gravel, then sand, then clay.) Why? (Answer: Because there are larger spaces between the gravel particles.)
2. If there were three rock units, one of gravel, one of sand, and one of clay, all containing the same quantity of water, in which would you drill a well? (Answer: Gravel. Water moves easier through gravel than sand or clay.)

Extension

Obtain 250 milliliters (mL) of sand, 250 mL of pea-size gravel, 250 mL of clay, and three large funnels (top diameter approximately 12 cm). Force a piece of cheesecloth into the top of the spout of each funnel. This will prevent material from going through the funnel spout. Put each funnel into separate clear containers so that the spout of the funnel is at least 5 cm above the bottom of the container. Pour the sand into the first funnel, pea-size gravel into the second funnel, and the clay into the third funnel. Pour equal amounts of water (approximately 200 mL) onto the materials contained in the funnels. Select three students to pour the water, creating a permeability race. Time how long it takes the water to flow through the materials. Record on a data sheet. Which material did the water flow through the fastest? Why?

This activity was adapted from "Get the Ground Water Picture," National Project WET.

HOW GROUND-WATER IS USED IN THE UNITED STATES



Total ground-water use in 1990, was 301,000 million liters per day.

Nationally, the largest use of ground water is Agricultural, followed by Domestic, Industrial, and Other Uses. Agricultural use includes ground water for irrigating crops and watering livestock. The Other Uses category includes ground-water use for mining and thermoelectric power. Only freshwater use is considered for this pie chart.

How does your State's ground-water use compare to the national uses identified in the pie chart?

ACTIVITY
Recharge - Discharge

Introduction

Recharge is the addition of water to an aquifer. Recharge can occur from precipitation or from surface-water bodies such as lakes or streams. Water is lost from an aquifer through discharge. Water can be discharged from an aquifer through wells and springs, and to surface-water bodies such as rivers, ponds, and wetlands. The following activity is designed to demonstrate the recharge and discharge of water to a model aquifer.

Objectives--Students will:

1. Identify several sources of recharge for ground water.
2. Identify several sources of discharge for ground water.
3. Discuss how water moves from recharge to discharge areas.
4. Discuss the connection between surface water and ground water.

Materials

1. One clear container at least 15-cm wide x 22-cm long x 6-cm deep for each group. Possible containers include clear plastic salad containers or clear baking pans.
2. Sufficient pea-size gravel to fill the container approximately 2/3 full.
3. Two 472-mL paper cups for each group.
4. One pump dispenser from soft-soap or hand-lotion containers for each group.
5. 472 mL of water.
6. Grease pencils, one for each group.
7. Twigs or small tree branches, to represent trees on the model (optional).
8. Colored powdered-drink mix or food coloring (optional).

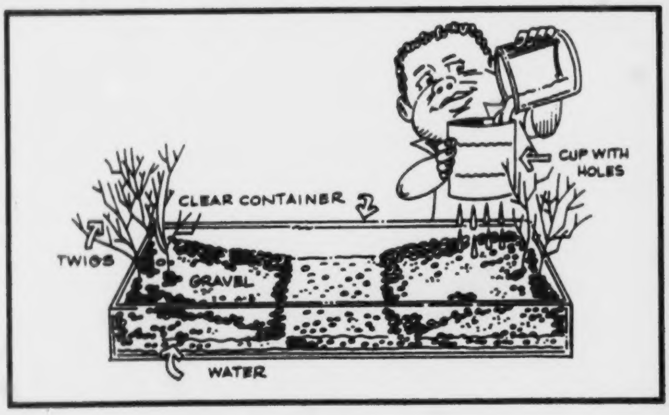
Teacher Preparation

1. Display a copy of the poster titled "Ground Water: The Hidden Resource" on the classroom wall several days prior to conducting this activity.
2. Using an ice pick or awl, punch 8 to 10 small holes in the bottom of one of the paper cups. When filled with water, this cup will be used to simulate rain.
3. Fill the clear containers 2/3 full with pea-size gravel.

Procedure

☛ Divide the class into small groups. Provide each group with one clear container filled 2/3 with pea-size gravel, one 472-mL cup with holes punched in the bottom, one 472-mL cup with no holes, and one pump dispenser.

☛ Students make models to represent hills and a valley. One student from each group fills the 472-mL cup without holes in the bottom with water. Each group makes a valley in the center of the model by pushing gravel to the farthest opposite ends of the container so the valley extends completely across the width of the container. About 2 cm of pea-sized gravel remains in the bottom of the valley.



- Explain to the students that the gravel mounds on both sides of the container represent hills with a valley in between. The students can place twigs or small branches on the hills to represent trees. Instruct a student to hold the 472-mL cup with holes over the model. Then add 472 mL of water to this cup. Tell the students that they are simulating rain. Have the students observe how the water infiltrates into the gravel and becomes ground water.

- Introduce the word recharge — the addition of water to the ground-water system. Observe that water is standing in the valley. Have the students use a grease pencil to draw a line identifying the water level in the container. The line should traverse the entire model, identifying the water level under the hills and in the valley. There will be a pond in the valley.

- Explain that they have just identified the top of the ground water in their model. The top of the ground water is called the water table. Discuss with the students how the ground water becomes a pond in the valley. This is because the water table is higher than the land surface (gravel) in the valley.

- Have the students insert the pump into one of the hills on the side of the valley, pushing the bottom down to the ground water. Allow each of the students in the group to press the pump 20-30 times after the water in the pump has begun to flow. Catch the water in the paper cup with no holes in the bottom. After each student takes a turn pumping, instruct them to observe the location of the water table in relation to the grease-pencil line. Where did the water go? What happened to the pond? Discuss discharge, the removal of water from the ground. Discuss the effect of ground-water pumping on streams and lakes.

Interpretive Questions

1. Where does ground water come from?

Answer: Precipitation (rain, snow, sleet, etc.) Also, if the water table is at or below the surface of the water in a stream or pond, water can move from the stream or pond to recharge the ground-water system.

2. What would happen in the students' neighborhood (name a local stream or pond) if a well was drilled near that stream or pond and enough water pumped to lower the water table around the stream or pond?

Answer: Some water from the stream or pond would be removed by the pump through the well. If enough water is removed, a pond or small stream could go dry.

Extension

Sprinkle a colored powdered-drink mix or food coloring on top of one of the hills and repeat the above activity by having it rain on the model. Discuss the movement of "pollution" from the hill to the ground water to the lake.

EPA ENVIRONMENTAL EDUCATION

ROLE OF PLANTS IN WATER FILTRATION

GRADE LEVEL: 4 – 7

BACKGROUND: Experiments can be done to show how a plume of dissolved materials can move through soil and enter a groundwater aquifer. But soil and plants have something of a dual role in this process. Depending on whether materials are dissolved or suspended in the water, soils and plant roots can remove some or all of this material as the water moves down through soil.

Most suspended materials will adhere to the soil. These may then be broken down and used as food by the plants. Dissolved nutrients, such as nitrogen or phosphorus, chemically bond with some types of soil particles. They are then taken up by plants, thus removing them from the soil before they can enter an aquifer. For the plants, these elements are food, for an aquifer, they are pollution.

Not all materials are absorbed by plants and not all water pollutants are food for plants. However, sediments from eroding soil, nutrients in human and animal wastes, and some components of household wastewater ("graywater") are excellent plant nutrients. Plants also use different nutrients at different rates, so that the amount of material they take up will depend on how much is dissolved in the water and how fast the water moves through.

This experiment is a very simplified way to show whether plants will take up certain kinds of materials from water moving relatively quickly through their root systems.

OBJECTIVE: To understand the role of plants in filtering the water moving through a watershed.

MATERIALS NEEDED:

- Six potted plants, with pots roughly six to eight inches in diameter, and holes in the bottom. These plants need to moderately dry, as if they had not been watered for a couple days. Plants with saturated soil will not absorb water, and very dry plants will absorb it all.
- Six clear containers, such as cups, which will support the plants and allow drainage to be viewed. You will need separate plants and cups for each of the materials in the water.
- Soil from outside (anywhere). The best soil is loamy, with smaller particles than sand.
- Unsweetened powdered drink mix, preferably grape or cherry for color.
- Vegetable oil.
- One or two different household cleaners (such as Comet/Ajax and Dish or Laundry soap).
  One should be liquid and the other powder.

PREPARATION: Set up the potted plants, each in its own cup. Slowly pour six to eight ounces of clean water through the pot, and check the percolation rate through the pot. Loosen or tighten the soil so that water percolates at about one ounce per minute. The rate should be fast enough to prevent long waiting periods, but slow enough not to carry very much soil through the pot.

PROCEDURE:

1. Place the potted plants into the top of their cups. Pour clean water slowly through one of the pots and watch it percolate through the bottom of the pot. The water should look as clean as what was poured.

2. Add a gram or so of soil to 6-8 ounces of water and stir so that the soil is well suspended and distributed in the water. Pour slowly into another flower pot. The water percolating through should look *much* cleaner than the dirty water poured.

3. Add about one ounce of vegetable oil to 6-8 ounces of water, stir (they won't mix completely) and pour into a third pot. See if the vegetable oil percolates through or is caught up by the plant roots.

4. Add some powdered drink mix to 6-8 oz. of water and pour through a fourth pot. See if the water percolating through retains the color.

5. Add some powdered cleanser to 6-8 oz. of water and pour through a fifth pot. Is the cleanser retained in the soil?

6. Add some liquid soap to the water (an ounce or so in 6-8 oz. water). Does the soap percolate through the soil?

7. Using the "contaminated" plants, pour some clean water at the same rate through each one (simulating a rain shower). Is more of the "pollutant" rinsed away from the soil by the clean water?

FOLLOW-UP QUESTIONS:

1. In what ways can plants and soil benefit drinking water quality?

2. We saw plants and soil remove some types of impurities from water. How might the plants remove larger quantities?

3. Can plants and soil remove any type of impurity from water?

4. What other organisms in the soil-plant system might aid the uptake of water pollutants?

5. What is the role of rainwater moving through contaminated soil?

EPA ENVIRONMENTAL EDUCATION

BUILD YOUR OWN AQUIFER

BACKGROUND:

Many communities obtain their drinking water from underground sources called **aquifers**. Water suppliers or utility officials drill wells through soil and rock into aquifers to supply the public with drinking water. Homeowners who cannot obtain drinking water from a public water supply have private wells that tap the groundwater supply. Unfortunately, groundwater can become contaminated by improper use or disposal of harmful chemicals such as lawn care products and household cleaners. These chemicals can percolate down through the soil and rock into an aquifer—and eventually into the wells. Such contamination can pose a significant threat to human health. The measures that must be taken by well owners and operators to either protect or clean up contaminated aquifers are quite costly.

NOTE: This demonstration should follow a class discussion on potential sources of pollution to drinking water supplies.

OBJECTIVE: To illustrate how water is stored in an aquifer, how groundwater can become contaminated, and how this contamination ends up in the drinking water well. Ultimately, students should get a clear understanding that what happens above the ground can potentially end up in the drinking water supply below the ground.

MATERIALS NEEDED:

1 6" x 8" clear plastic container that is at least 6-8" deep (shoebox or small aquarium)
1 lb. of modeling clay or floral clay
2 lbs. of white play sand
2 lbs. of aquarium gravel (natural color if possible) or small pebbles
(Hint: As many small rocks may have a powdery residue on them, you may wish to rinse and dry them on a clean towel prior to use. It is best if they do not make the water cloudy.)

1 drinking water straw
1 plastic spray bottle (be sure the stem that extends into the bottle is clear)
1 small piece (3" x 5") of green felt
1/4 cup of powdered cocoa
Red food coloring
1 bucket of clean water and a small cup to dip water from bucket
Scotch tape

PROCEDURE:

1. To one side of the container, place the drinking water straw, allowing approximately 1/8" clearance with the bottom of the container. Fasten the straw directly against the long side of the container with a piece of tape. Explain to the class that this will represent two separate well functions later in the presentation (if not placed at this time, sand will clog the opening).

2. Pour a layer of white sand completely covering the bottom of the clear plastic container, making it approximately 1½" deep. Pour water into the sand, wetting it completely, but there should be no standing water on top of the sand. Let students see how the water is absorbed in the sand, but remains around the sand particles as it is stored in the ground and ultimately in the aquifer.

3. Flatten the modeling clay (like a pancake) and cover half of the sand with the clay (try to press the clay into the three sides of the container in the area covered). The clay represents a **"confining layer"** that keeps water from passing through it. Pour a small amount of water onto the clay. Let the students see how the water remains on top of the clay, only flowing into the sand below in areas that the clay does not cover.

4. Use the aquarium rocks to form the next layer of earth. Place the rocks over the sand and clay, covering the entire container. To one side of the container, slope the rocks, forming a high hill and valley (see illustration below). Now pour water into your aquifer until the water in the valley is even with your hill. Let students see the water around the rocks that is stored in the aquifer. They will also notice a **"surface"** supply of water (a small lake) has formed. This will give students a view of the ground and surface water supplies, both of which can be used for drinking water purposes.

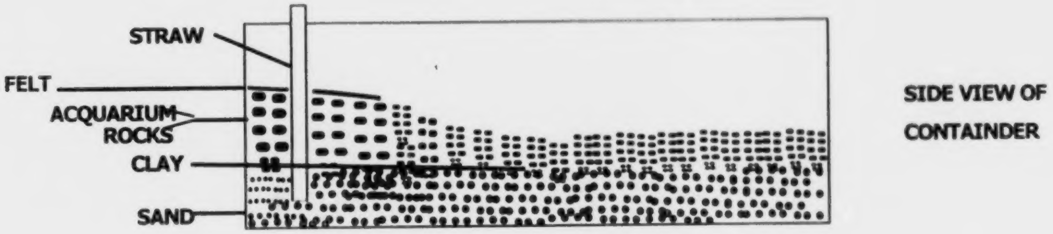
5. Next, place the small piece of green felt on top of the hill. If possible, use a little clay to securely fasten it to the sides of the container it reaches.

6. Sprinkle some of the cocoa on top of the hill, explaining to students that the cocoa represents improper use of things like lawn chemicals or fertilizers.

7. Put a few drops of the food coloring into the straw, explaining to students that people often use old wells to dispose of farm chemicals, trash, and used motor oils. Students will see that it colors the sand in the bottom of the container. This is one way that pollution can spread through the aquifer over time.

8. Fill the spray bottle with water. Make it rain on top of the hill and over the aquifer. Quickly students will see the cocoa (pesticide/fertilizer) seep down through the felt and also wash into the surface water supply.

9. Take another look at the well you contaminated. The pollution has probably spread farther. Remove the top of the spray bottle and insert the stem into the straw. Depress the trigger to pull up the water from the well. (Water will be colored and "polluted.") Explain that this is the same water that a drinking water well would draw for them to drink.



BLUE THUMB

Give drinking water a hand

TEACHER/ STUDENT GUIDE

Building a Model Aquifer

Background

Although nearly half of all Americans get their drinking water from wells, many people have never heard of ground water. Use of ground water supplies is increasing at twice the rate of surface supplies, and the trend is expected to continue. Until the late 1970's, it was widely believed that ground water was protected from contamination by the natural filtering effect of the many layers of soil, sand, gravel and rocks. We now know that pollutants can travel through all these layers. Incidents of serious contamination have been reported in every state in the nation.

Objective

The student will use a model of an aquifer to describe how ground water flows through an aquifer, how ground water can become contaminated, and why it is so difficult to clean contaminated ground water.

Teacher Suggestions

This model can be a very flexible tool which will allow students to simply study groundwater flow, look at how well placement affects yield, or examine how ground water is vulnerable to contamination.

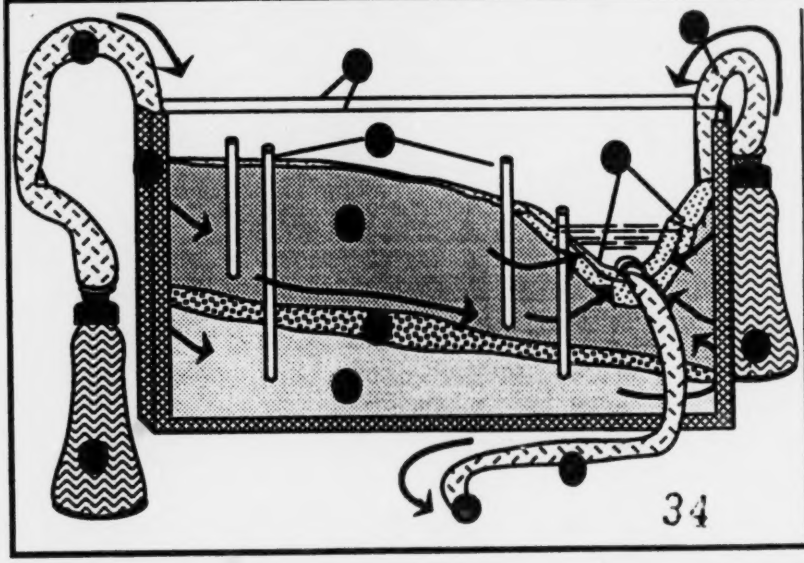
Depending on resources, the teacher may lead groups of four or five students in building their own models as described below, or the teacher may build a single, larger (the longer the better) version for demonstration. If students are able to make their own models, then it would create less traffic and crowding if all materials for students 1 - 4 are placed at different stations around the room. Then it will be easier for each group to pick up what they need and take it back to their own work area.

Begin by orienting the students to how the earth looks below the surface, demonstrating a working model and relating its parts to a diagram of the hydrogeologic cycle. Using unassembled materials, go over the basic assembly plan illustrated in Steps 1 - 9 on the back, briefly showing students how to put the model together. Then divide students into groups to build their own model.

Student Activities - Model Assembly

For a group having four or five students, responsibilities may be divided among students as below.

Station/student 1 - get two plexiglass panels (one with hole in it), duct tape, and ruler and begin assembling model as shown in steps 1 to 4 on back.



List of Materials (per model)

1 Two plexiglass panels - 10" x 20".
In one panel, drill a 3/8" hole located 5" from top and 5" from the edge.
2 Duct Tape - 2-1/2" wide roll
3 Lightweight felt-10" x 20" sheet rolled into tube
4 Sand - about 3 quarts
5 Pea gravel - about 2 quarts
6 Foam weatherstrip (Open-cell) 3/4" wide, with or without adhesive backing
7 Two 6" pcs. tubing - 1/2" inner diameter (I.D.)
8 One 6" pc. tubing - 1/2" outer diameter (O.D.)
9 Clear drinking straws or glass tubing
10 Ruler
11 Two dish soap bottles with bottom cut out.
12 Food coloring - at least three colors
13 Syringe or tap aspirator
14 Cups - 4 oz. paper and large (16oz) plastic

Station/student 2 - collect plastic soap bottles, tubing (1/2" I.D. and 1/2" O.D.), foam strips, and syringe or other aspirator. Force foam up about one inch into each of the large (1/2" I.D.) pieces of tubing for use in step 5.

Station/student 3 - collect sand, gravel, felt sheet and straws. Soak felt sheet in water, wring out, then roll the sheet into a tight coil about 3/4" thick and 20" long. Use in step 6.

Station/student 4 - First help Student 1 with assembly steps 1 to 4, then get food coloring, water supply, cups.

Student 5 - Help with model assembly in steps 1 to 9.

Once the model is assembled, and water is flowing through the sand, into the river valley and out of the collector tube, do the activities described on back.

Investigations

1. Which wells have the most water in them? Raise the water supply bottles as high as possible without pulling out the tubing - what happens to the water level in each of the wells and to the amount of water coming out of the collector tube? Next, lower the bottles and observe what happens. How does the height of the water supply relate to water flow rate?

2. Pour out half of the water from the supply bottles, mark the water level, then pour a 4 ounce cupful of water into each bottle. Every few minutes, as the water reaches the mark, pour in another cupful of water. Also measure the total amount of water added during the time periods before the dye appears in water from the collector tube and after the dye is no longer visible in water from this tube.

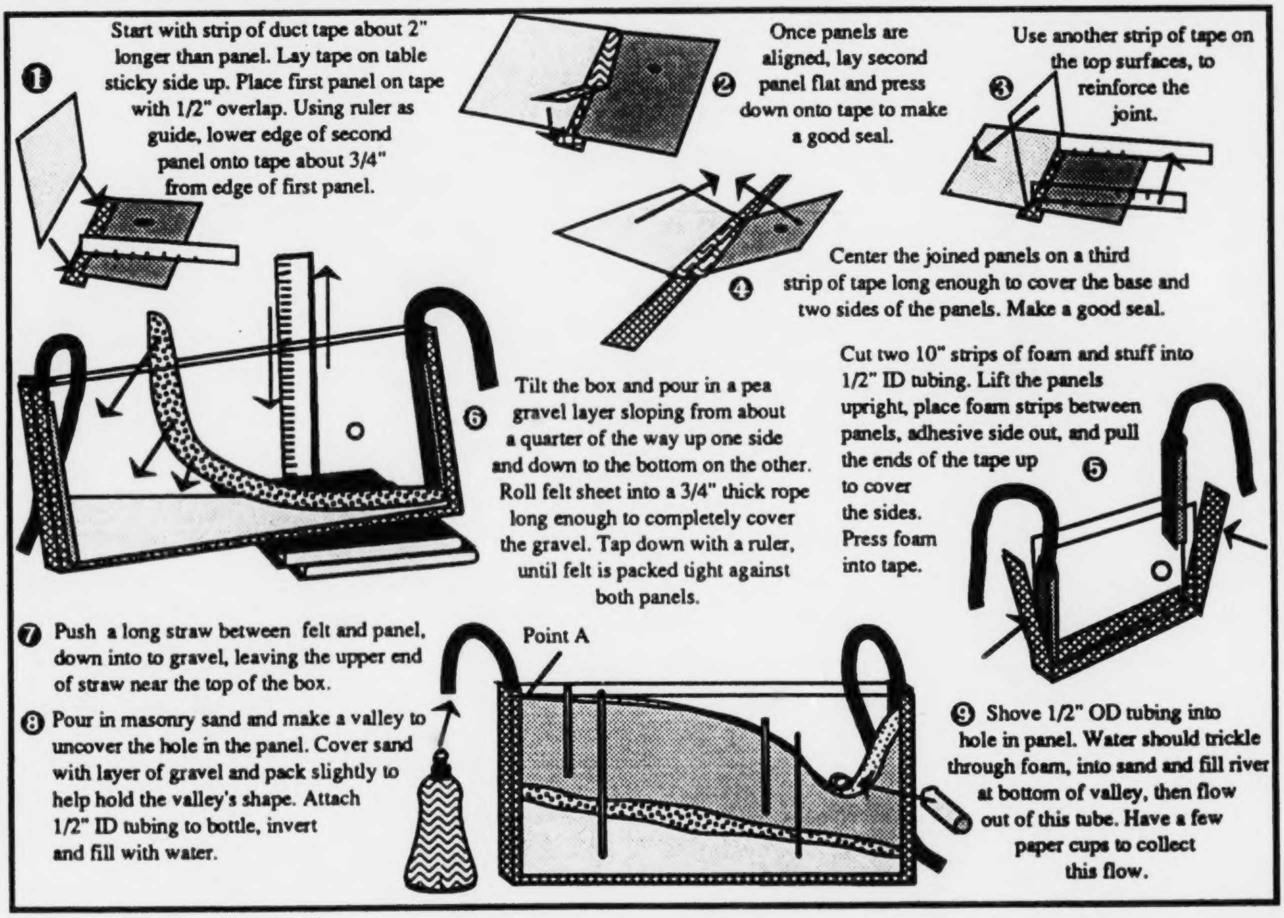
3. At the same time, place four drops of food coloring on the sand at Point A shown in the assembly diagram for Steps 7 - 9. On the plexiglass, mark the point with a water soluble marker. Every two minutes, make a mark on the plexiglass at the front edge of the dye as it moves through the sand. Measure the distance between the marks and record the distance moved per unit time.

4. Ask your teacher to show you how to do a 10-tube series of 1:10 dilutions of food color in water. Number each tube 1 to 10. Use this series as a guide for estimating the concentration of dye in the water coming out of the collector tube. After the dye you added in Step 3 above begins to appear in the water from the collection tube, collect a sample in a test tube every two minutes. Compare the color of this sample with each tube in the dilution series and record the number of the tube which is nearest in color of your sample. This will be the concentration of your sample.

5. Graph your data, plotting time on the x-axis and dye movement on the y-axis. Also plot time vs. concentration after dye appears in water coming out of the collector tube. What does your data tell you about how long it takes for ground water to get clean after being contaminated?

Clean Up

First, empty any water in the water supply bottles into the model and remove bottles and tubing. Then, place screen over a bucket and flush sand and gravel onto screen - use a screen with a mesh large enough to allow sand to sift through but small enough to catch the gravel. Rinse out foam strips and felt roll.



① Start with strip of duct tape about 2" longer than panel. Lay tape on table sticky side up. Place first panel on tape with 1/2" overlap. Using ruler as guide, lower edge of second panel onto tape about 3/4" from edge of first panel.

② Once panels are aligned, lay second panel flat and press down onto tape to make a good seal.

③ Use another strip of tape on the top surfaces, to reinforce the joint.

④ Center the joined panels on a third strip of tape long enough to cover the base and two sides of the panels. Make a good seal.

⑤ Cut two 10" strips of foam and stuff into 1/2" ID tubing. Lift the panels upright, place foam strips between panels, adhesive side out, and pull the ends of the tape up to cover the sides. Press foam into tape.

⑥ Tilt the box and pour in a pea gravel layer sloping from about a quarter of the way up one side and down to the bottom on the other. Roll felt sheet into a 3/4" thick rope long enough to completely cover the gravel. Tap down with a ruler, until felt is packed tight against both panels.

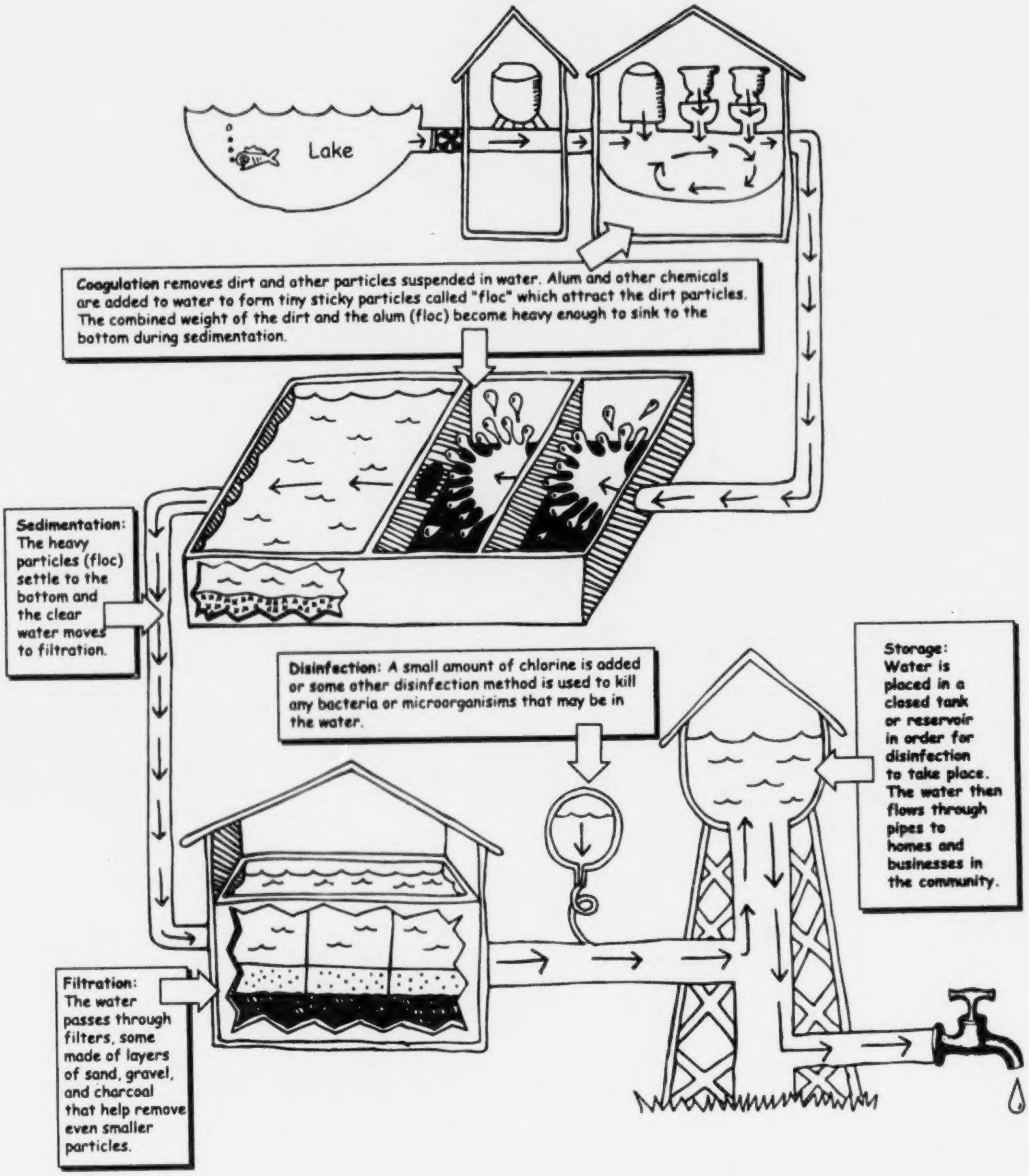
⑦ Push a long straw between felt and panel, down into to gravel, leaving the upper end of straw near the top of the box.

⑧ Pour in masonry sand and make a valley to uncover the hole in the panel. Cover sand with layer of gravel and pack slightly to help hold the valley's shape. Attach 1/2" ID tubing to bottle, invert and fill with water.

⑨ Shove 1/2" OD tubing into hole in panel. Water should trickle through foam, into sand and fill river at bottom of valley, then flow out of this tube. Have a few paper cups to collect this flow.

Blue Thumb Water Treatment Plant

Follow a drop of water from the source through the treatment process. Water may be treated differently in different communities depending on the quality of the water which enters the plant. Groundwater is located underground and typically requires less treatment than water from lakes, rivers, and streams.



Coagulation removes dirt and other particles suspended in water. Alum and other chemicals are added to water to form tiny sticky particles called "floc" which attract the dirt particles. The combined weight of the dirt and the alum (floc) become heavy enough to sink to the bottom during sedimentation.

Sedimentation: The heavy particles (floc) settle to the bottom and the clear water moves to filtration.

Disinfection: A small amount of chlorine is added or some other disinfection method is used to kill any bacteria or microorganisims that may be in the water.

Storage: Water is placed in a closed tank or reservoir in order for disinfection to take place. The water then flows through pipes to homes and businesses in the community.

Filtration: The water passes through filters, some made of layers of sand, gravel, and charcoal that help remove even smaller particles.

BEST COPY AVAILABLE

Toothbrush

Turn off the water when you brush your teeth and save 2 U.S. gallons or about 8 liters of water.

Lawn Sprinkler

Water the lawn before 10 a.m. and never when it's windy. Adjust sprinklers to water only the lawn, never the street, sidewalk or house.

Hands

Turn off the water when you wash your hands and save one U.S. gallon or 3.8 liters of water. Everyone has a Blue Thumb. Everyone needs to lend a hand to keep our water resources fit and healthy.

Garden Hose

Put a shut-off nozzle on your hose to control the flow.

Shower

Take shorter showers. Install a low-flow shower head.

Water Pitcher

Fill a pitcher with water and put it in the fridge, instead of running the water every time you want a drink.

Fish Tank

When changing the water in a fish tank, save it and water plants with it.

Car

Use a bucket of water, soap and a hose with a shut-off nozzle to wash the car.

Take used motor oil and old car batteries to an automotive recycling center.

Driveway

Use a broom to clean the driveway or sidewalk instead of a hose.

Faucet

Fix leaky faucets.

Trash

Don't use the toilet for a trash can.

2–7 U.S. gallons or about 8–27 liters of water are needed every time you flush the toilet.

Cans of Paint

Never pour down the drain or throw in the trash.

Take your leftover paint to a community group that can use it or to a hazardous waste collection center.

Dishwasher

Run the dishwasher only when full. Partial loads use the same amount of water as full loads.

Household Batteries

Never throw in the trash. They contain lead, mercury, and cadmium. Take to a hazardous household waste collection center.

Bath Tub

Taking a shallow bath uses less water than taking a shower.

Clothes Washer

If your washing machine doesn't have settings for different load sizes, always wash full loads.

Fruits & Vegetables

Fill a pan of water and use it to wash fruits and vegetables instead of letting the water run.

Wind

Never water your lawn when it's windy.

Hazardous Household Products

Never pour down the drain, put on the ground or toss in the trash.

Take potential water polluters such as oven cleaners, mothballs, paint strippers and bug sprays to a hazardous household waste collection center.

Rain

Save rain water to water plants.

Garden

Use garden pesticides sparingly.

Follow package directions carefully.

Try natural means of controlling gardens pests instead of pesticides.

River

Never throw trash or garbage in a river, lake, stream or canal.

Pick up trash or garbage around a river, lake, stream or canal.

Washing Dishes

Washing dishes by hand often uses more water than using a dishwasher, especially if you let the water run.

Bugs

Use a fly swatter instead of bug spray.

Blue Thumb Thinking

Almost 80 percent of the earth's surface is covered with water, but less that 1 percent is fresh water that we can actually use for drinking, irrigating crops, recreation, industrial uses, and other purposes. 99% of the earth's water is in oceans or frozen in polar ice caps. That's why it is very important that we conserve and protect our fresh water supplies.

You can play a part in taking care of our water resources. Spread the word that taking shorter showers or lowering the level of water in your bath can help to save water. Tell your family that batteries should not be thrown into the trash because they contain harmful heavy metals. At the landfill, the batteries can corrode and release cadmium and mercury that can leach into water and pollute it.

Knowing about water clears up a lot.

Create sentences about water that start with the letter indicated. Then "spread the word for water" and share your statements with other students, family members, and friends.

For more information on conserving and protecting our water resources, join the Blue Thumb Club. Write to Blue Thumb Club
American Water Works Association
Public Affairs Department
6666 W. Quincy Ave.
Denver, CO 80235

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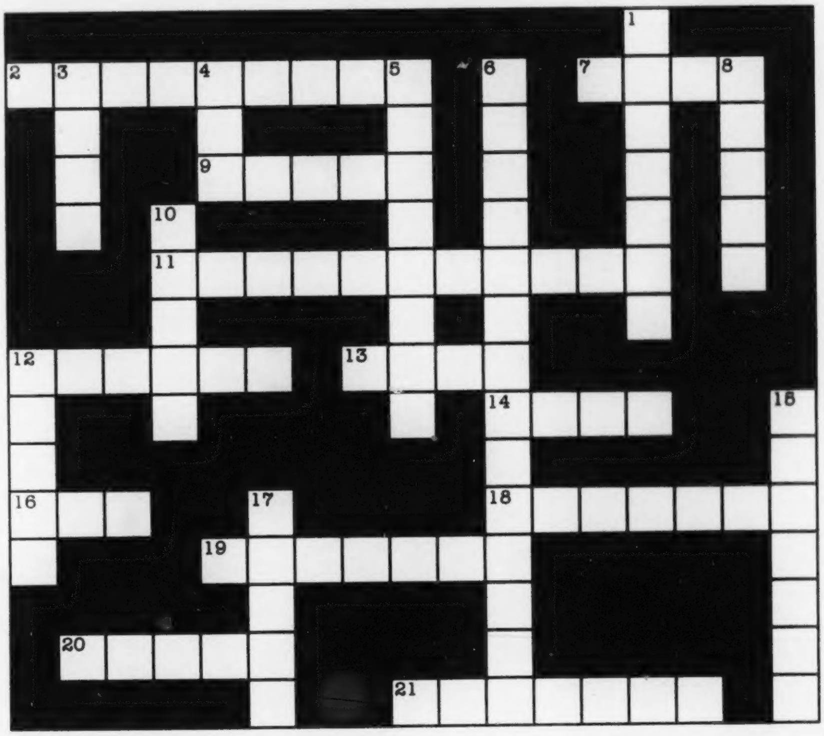
M

B

Blue Thumbs Count

A Blue Thumb is to water what a green thumb is to plants. Both are about making something better. When you act in ways that have a positive effect on drinking water, you are using your **Blue Thumb.** Drinking water counts on you to use your **Blue Thumb** at home, at school and everywhere in between. Complete the puzzle to discover what really counts when it comes to conserving and protecting our water resources.

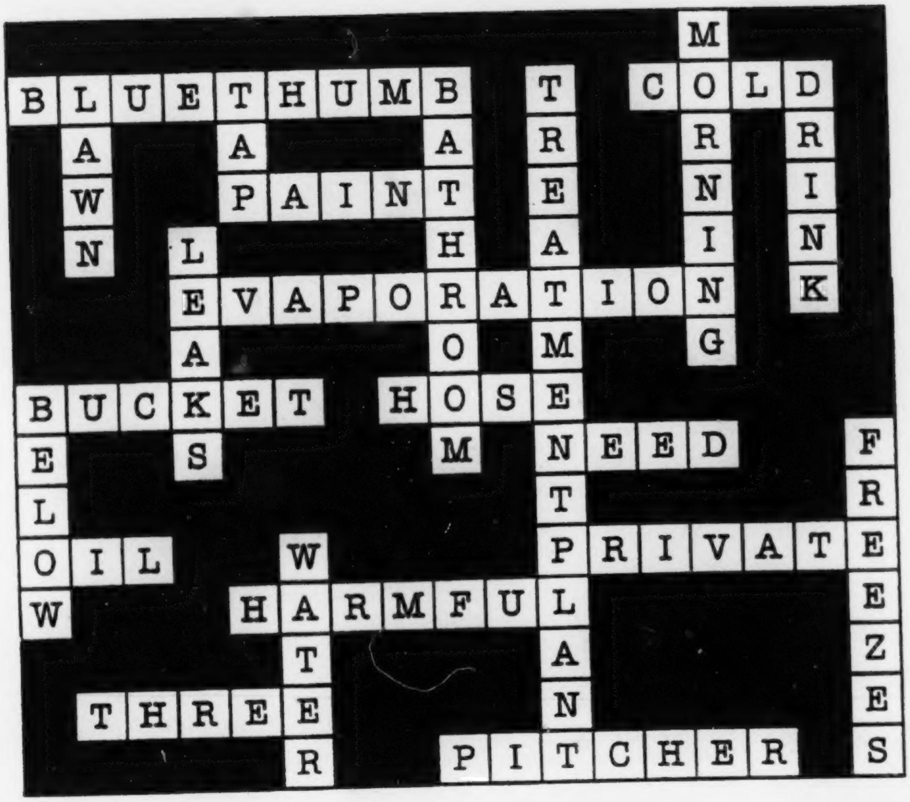


Across

2. Use this to show you care for water (2 words).
7. Always run your tap until the water is ______ before drinking it.
9. Save leftover hobby supplies, like this, and dispose of them at a special collection center.
11. Water that turns to vapor and rises to the sky.
12. Use this to wash your bike rather than let the hose run.
13. Put a nozzle on this to save water.
14. All living things _____ water.
16. Motor ____ should be taken to a service station for recycling.
18. Most people get their water from a public water utility; but some people use ______ wells.
20. Water occurs in ______ states: solid, liquid and gas.
21. You can fill this with water and put it in your refrigerator to keep water cold.

Down

1. Best time of the day to water the lawn or flowers.
3. Don't water this when you expect it to rain.
4. Turn this off while you brush your teeth.
5. Room in your house that uses the most water.
6. Place where water is cleaned and treated for drinking (2 words).
8. Consume a beverage, like water.
10. Inspect all pipes and toilets for these.
12. Aquifers are _____ ground.
15. At 32 degrees Fahrenheit/ 0 degrees Celsius, water does this.
17. 80% of the Earth's surface is covered with this.


BLUETHUMB
COLD
PAINT
EVAPORATION
BUCKET
HOSE
NEED
OIL
PRIVATE
HARMFUL
THREE
PITCHER
MORNING
DRINK
LAWN
TAP
BATHROOM
TREATMENT
PLAN
LEAKS
BELOW
WATER
FREEZES

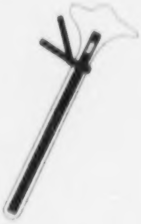
Water Contamination Experiment

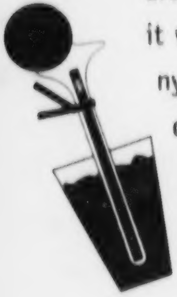
Materials Needed

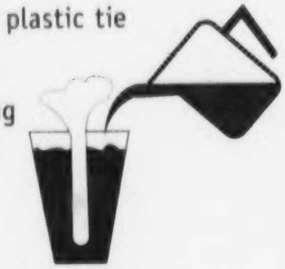
- *Cup for each student*
- *6 inches (150 millimeters) of nylon net per student*
- *Plastic tie for each student*
- *One eyedropper for every three students*
- *One bottle of vegetable-oil food dye (red, green or blue) for every three students*
- *Enough water to fill each student's cup*
- *Enough potting soil to fill each student's cup*
- *Pencil for each student*

Activity Directions

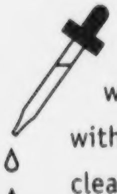
Students should wrap the nylon around their pencil and secure it with a plastic tie. Put the nylon-wrapped pencil in the middle of the cup, so it can act as a "well." Carefully place the soil in the cup around the nylon-wrapped pencil. Finally, untie the plastic tie and slip the pencil out of the soil (allowing the nylon to remain in the hole) and pour water into the cup.

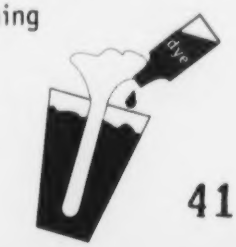


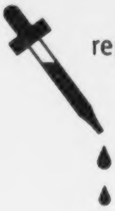




After a few minutes, the water should appear in the opening of the well. Students should remove water with the eyedropper and see that it is clear in color. After returning the water to the well, students can add a drop of food dye to the surrounding soil to represent contamination. After a few minutes, remove water again with the eyedropper. This time the water should have color in it from the dye.







Questions to Expand Students' Thinking

- What would happen to the lakes and rivers that are fed by water from this aquifer?
- What types of things in your household, if poured on the ground, might contaminate drinking water?
- Should you throw toxic household items in the trash?

Count on Blue Thumb for More

If your class or youth group wants to learn more about how drinking water counts on everyone to use their Blue Thumbs to protect our water resources, visit our Web site:

http://www.awwa.org/bluethum.htm

or write to:

Blue Thumb Club
American Water Works Association
6666 West Quincy Avenue
Denver, CO 80235
(303) 794-7711, ext. 6284

BLUE THUMB
GIVE DRINKING WATER A HAND

Activity source: Intermediate Te 3DX, American Water Works Association

Water Contamination Experiment

The following experiment is designed to help young people understand how drinking water counts on them to prevent water pollution.

Objective *Young people will create a miniature well so they can observe the effects of groundwater contamination.*
Taxonomy Level *Comprehension*
Time Needed *30 minutes*

Teacher's Notes

Approximately 53 percent of the population in the United States gets its water from underground aquifers. An aquifer is a geological (created by rocks) formation containing water. Like the holes in a sponge, an aquifer has openings or pores that can store water. Water for drinking is drawn up to the surface by a well or spring. The world's largest aquifer is the Ogallala Aquifer, which extends from Nebraska to Texas.

Since water seeps down through soil into the aquifer, the soil filters the water. But, many activities threaten the safety of this source of drinking water. Gasoline and other harmful liquids have been allowed to leak from underground storage tanks into the groundwater supply. Pollutants can seep into groundwater from poorly constructed landfills or septic systems. Groundwater can also be polluted by runoff from fertilized fields or livestock areas. Homeowners unknowingly contribute to groundwater contamination by dumping toxic chemicals down the drain or pouring them on the ground.

[redacted]

THUMB BLUE BLUE THUMB

Give drinking water a hand.

CLASSROOM ACTIVITY: CONSERVATION

The following activity is offered to help students understand how they can give drinking water a hand.

Objective
Students will learn how much water can be wasted from a leaky faucet.

Taxonomy Level
Application

Time Needed
20 minutes of activity. One night to fill bucket.

Teachers' Notes
An average leaky bathroom or kitchen faucet can waste up to 2000 gallons of water a year. The leaking faucet can usually be repaired by replacing a washer (a rubber seal) that fits over the pipe. If every household in America had a faucet that dripped once each second, we would waste 928 million gallons a day or enough water to fill an eight ounce glass almost 7.5 billion times.

Materials Needed
Bucket
Cup
Faucet and sink that is connected to water
Tape
Markers

Activity Directions
Have the students get a bucket and have them put one cup of water in the bucket. Then, on the outside of the bucket, have the students mark on a piece of tape the level of water for one cup. Next, have them mark the level for two to eight cups of water. Empty the bucket.

Now place the bucket under a faucet and explain that you are going to leave the faucet dripping for the rest of the day, just the way a leaky faucet might drip. Ask the class to give an estimate of how many cups of water you will waste by doing this experiment. Have the students put their estimates on pieces of tape and attach to the opposite side of the bucket. Do not come back to look at their estimates. This exercise is designed to allow them to feel comfortable doing mathematical estimates.

Then, turn on the faucet just enough to let it drip. At the end of the day, or the next day, have the students find out how many cups of water are in the bucket.

Questions to Expand Students' Thinking
What activities do you do in your home that waste water?

How much water would have been wasted if you had let the faucet drip over the weekend? Over summer vacation?

How can we best use the water we have collected in the bucket, rather than pouring it down the drain?

Source: Water's Magic, Mary Haberman, AWWA, 1991, Catalog 70060DX, American Water Works Association, 6666 West Quincy Avenue, Denver, CO 80235

[redacted]

FOR KIDS

Blue Thumb Word Search

Most people in North America get their water from a public water utility. Public utilities are companies or government agencies that supply needs such as electricity, gas, or water to the public. Water utilities get their water from rivers, lakes, reservoirs, or underground aquifers. Often, the water must be treated to make it safe to drink.

We reuse the same water over and over and it can become polluted by people and industry. Even deep underground aquifers can be polluted from the surface. For example, many household items, such as car wax, spot remover, or floor polish, should not be poured down the drain or thrown out in the trash. Even lawn chemicals and other garden toxins used outdoors can contaminate water sources by running off the land into storm drains. And water can end up in lakes and rivers.

Let's take care of our water resources. Use your "Blue Thumb" to conserve water, protect it, and get involved.

New Vocabulary Words:

water sources – bodies of water such as lakes, rivers, reservoirs, and underground aquifers from which we draw water for drinking

treatment – a series of chemical and physical processes to remove dissolved and suspended solids from raw water to produce safe water to drink

contaminate – to make unsafe for drinking

pesticide – a chemical used to kill pests

hazardous – dangerous or harmful

Give drinking water a hand.

Can You Find These Words?

(circle each one)

nature
drink
toxic
fertilizer
paint
gasoline
clean
treatment
tap
protect
water sources
recycle
pesticide
oil
batteries
contaminate
hazardous
wells
leaks
pollute
safe

W	E	L	L	S	D	M	P	Q	S	V	F
L	A	B	O	T	P	O	L	L	U	T	E
H	Z	T	R	E	A	T	M	E	N	T	R
C	P	A	E	R	I	C	B	C	U	E	T
O	Y	P	C	R	F	E	N	L	K	D	I
N	A	H	Y	J	S	T	M	E	H	I	L
T	E	A	C	P	Z	O	C	A	L	C	I
A	F	Z	L	K	T	R	U	N	T	I	Z
M	A	A	E	D	O	P	E	R	B	T	E
I	S	R	I	X	X	N	W	G	C	S	R
N	M	D	P	A	I	N	T	S	L	E	V
A	B	O	I	L	C	F	S	M	O	P	S
T	F	U	O	D	R	I	N	K	T	E	S
E	D	S	L	M	O	H	J	L	A	M	R
P	A	T	B	A	T	T	E	R	I	E	S
G	K	U	E	F	N	A	T	U	R	E	L

Búsqueda de Palabras

La mayoría de la población de américa del norte obtiene su agua de una agencia publica. Estas agencias publicas son compañías o departamentos del gobierno que suplen ciertas necesidades como agua, gas y electricidad al publico. Estas agencias obtienen el agua de ríos, lagos y pozos. Generalmente el agua tiene que ser tratada (para limpiarla) para que sea potable.

Todos podemos usar El Pulgar Azul para proteger este recurso natural. Nosotros usamos el agua mas de una vez, pero el agua se puede contaminar por nuestro mal uso y el de la industria. Aun las fuentes de agua subterráneas mas profundas se pueden contaminar con acciones en la superficie. Por ejemplo: muchos productos caseros como la cera de automóviles, quitador de manchas o pulimentos para el piso no deben de ser descartados en el desague de la casa ni se deben de botar a la basura. Los productos químicos para el jardín y otros productos tóxicos usados fuera de la casa pueden contaminar el agua que tomamos si son llevados por la lluvia la calle y de ahí a formar parte del agua subterránea o de ríos o lagos.

Mantengamos presente todos los días El Pulgar Azul y conservemos el agua como un recurso natural esencial.

¿Puede encontrar estas palabras?

(dibuje un circulo alrededor de cada una después de encoutrarla)
(¿puede encontrar mas? ¡sí hay! por lo menos 14 mas)

contaminar
tóxico
pintura
pozos
gasolina
cera
salideros
baterías
baño
fertilizantes
abono
agua
natural
tomar
químicos
fuentes
reciclar
El Pulgar Azul

S	A	I	R	E	T	A	B	P	S	L	E	H	C
F	I	E	L	O	C	I	X	O	T	I	L	V	A
U	E	S	J	O	S	E	C	Z	U	M	P	E	I
E	A	R	E	C	G	I	T	O	Y	P	U	C	C
N	R	M	T	E	M	I	U	S	O	I	L	L	U
T	A	A	P	I	N	T	U	R	A	A	G	U	S
E	N	S	U	G	L	O	L	A	M	B	A	D	A
S	I	Q	M	A	F	I	N	A	T	U	R	A	L
A	M	O	E	S	P	A	Z	R	G	E	A	R	I
S	A	L	N	O	N	O	B	A	E	N	Z	U	D
O	T	M	O	L	P	U	R	A	N	O	U	L	E
J	N	A	S	I	R	R	A	M	O	T	L	A	R
I	O	S	E	N	R	A	L	C	I	C	E	R	O
H	C	L	B	A	Ñ	O	B	U	E	N	O	S	S

Blue Thumb Word Scramble

Put the letters in the right order to complete a Blue Thumb thought!

All living things need ______________ to live.
tawer

When water evaporates, it travels into the air and becomes part of a ______________.
dlocu

Less than 1% of all the water on earth is ______________ water.
sefrh

We ______________ water in the liquid form.
ikrdn

Check for leaks and save hundreds of ______________ of water a day.
glloans

You'll save water by taking a quick ______________.
howser

Wash bikes and cars with a ______________ and sponge instead of a running hose.
kecbut

Ask your ______________ to look for ways to save water.
mfaiyl

How much water do we use in a day?

Taking a bath or shower	15-30 gallons
Watering the lawn	180 gallons
Washing the dishes	15-60 gallons
Washing clothes	30 gallons
Flushing the toilet	4-7 gallons
Brushing teeth	1 gallon
Drinking	1/2 gallon

LET IT BE
NATURE

Palabras de Letras Mezcladas

Ponga las letras en orden y complete un pensamiento Pulgar Azul.

Todo lo que vive necesita ______________ para vivir.
GAUA

Si el agua se evapora y escapa a la atmosfera se convierte en ______________.
SBUNE

Menos del 1% de toda el agua en la tierra es agua ______________.
LDUEC

Nosotros tomamos agua que es un ______________.
QLIUODI

Cerrando los salideros se pueden ahorrar cientos de ______________ de agua.
GLNOESA

Ayude a ahorrar agua tomando una ______________ rápida.
HACDU

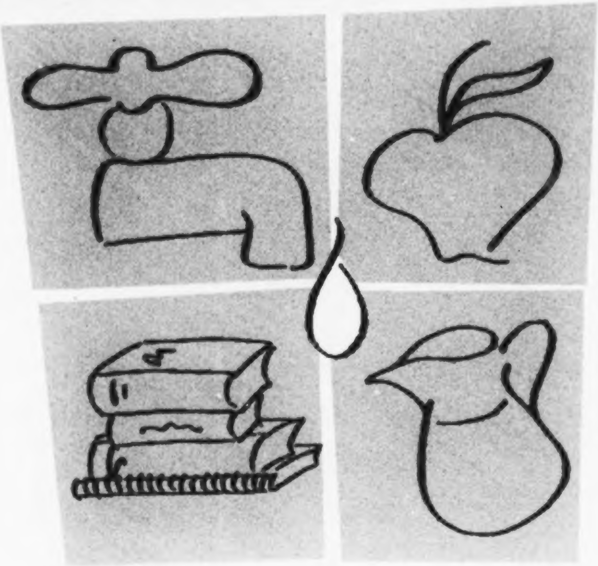
Lava los carros y bicicletas usando una ______________ y una esponja.
BTEAUC

Pídale a su ______________ que lo ayude a ahorrar agua.
FILIAMA

¿Que cantidad de agua usamos al día?

Bañarnos	15 a 30 galones
Regar la grama	180 galones
Lavar platos	15 a 60 galones
Lavar ropa	30 galones
Tomar agua	1/2 galón
Lavar los dientes	1 galón

Drinking Water Activities: 8-12



SOURCE WATER PROTECTION:
Surface Water Sources

9-12

OBJECTIVES

The student will do the following:

1. Identify sources of contamination to water.
2. Describe management methods to protect water supply sources.
3. Develop a plan to improve watershed management.

SUBJECTS:
Science (Ecology, Physical Science), Social Studies (Economics, Government)

TIME:
2 class periods
field trips

MATERIALS:
student sheets
bus for field trip
writing materials

BACKGROUND INFORMATION

Many towns and cities obtain their drinking water from a nearby river, lake or reservoir. The quality of this source water is influenced by the quality of streams flowing into it, the land uses and activities conducted near it, and any air deposition that might occur.

EPA's Source Water Protection (SWP) Program was established to help states and communities protect their drinking water supply sources. Surface source water protection is a 3-step process involving: delineating areas contributing water to a surface water intake, identifying potential contaminant sources that may threaten the water supply, and protecting the supply using a combination of watershed management strategies for specific communities or watersheds. (Since water does not flow only within politically-established boundaries, some strategies may extend beyond these boundaries and address the entire watershed.)

Watershed management strategies incorporate broad concepts such as land use control and/or management, best management practices, and pollution prevention. They emphasize prevention of both point source and nonpoint source contamination. Specific watershed management strategies may include the following or others: protection of inland wetlands that serve as filters for pollutants, appropriate forestry management practices, erosion controls, control of adjacent zoning and urbanization, creation of buffer zones along reservoir edges, reservoir access and activity control, and community education. Homeowners, businesses, farmers, and industries may also be encouraged to use pollution prevention and best management practices to prevent surface water contamination.

Source: Water Sourcebook; Copies available by calling (770) 426-8936, Ext. 234
or visit www.griffin.peachnet.edu/waterwise/wwc.htm

Terms

best management practices (BMPs): techniques that are determined to be currently effective, practical means of preventing or reducing pollutants from point or nonpoint sources, in order to protect water quality. BMPs include, but are not limited to structural and nonstructural controls, operation and maintenance procedures, and other practices. Usually, BMPs are applied as a system of practices rather than as a single practice.

buffer zone: an area between the water supply source and the possible contamination sources where no contamination activities are likely to occur

pollution prevention: preventing the creation of pollutants or reducing the amount created at the source of generation, as well as protecting natural resources through conservation or increased efficiency in the use of energy, water, or other materials

Source Water Protection: process that involves delineating areas contributing water to a water well or surface water intake; identifying potential contaminant sources that threaten the water supply; and using management strategies to protect the source water from contamination. Source water protection is applied to both surface water and groundwater supply sources.

watershed: land area from which water drains to a particular surface waterbody

zoning: to divide into areas determined by specific restrictions; any section or district in a city restricted by law for a particular use

ADVANCE PREPARATION

1. Copy Student Sheets.

2. Arrange for field trips.

PROCEDURE

I. Setting the stage

  A. Discuss Background Information with students.

  B. Contact the local drinking water treatment plant and find out the water source in the community.

II. Activity

A. Schedule a visit to the water supply reservoir with a water system representative and ask about source water protection methods that are used, including upstream management methods in the watershed. If a field trip is not possible, have a water system representative visit the class.

B. From local, state, or other sources, define the water supply watershed on a topographic or other map and locate potential pollutant sources. (Use Student Sheet to determine potential pollution problems.)

C. Visit each pollutant source, or a location downstream of each one, to determine the type and extent of pollutants to the reservoir. (Students could be assigned this as an out-of-class assignment and report to the class.)

D. Note any pollution prevention or best management practices in place or, where none exist, make notes of recommendations (not just what is needed but how to do what is needed).

E. Make a compilation of all notes from the class into a report on protection of the water supply watershed. Include recommendations as to the location and type of pollution prevention or best management practices used or needed, and other water quality management steps which should be taken.

III. Follow-up

Share compiled information or reports with local watershed managers and ask them to comment on the class ideas.

IV. Extensions

Have students construct a solar evaporator using the materials you have provided or some they may want to bring to class. They can follow the directions on the Student Sheet or try their own design. Students should wash hands and dip a finger in salt solution and taste. Place solar evaporators in a warm, sunny place for 24 hours. Taste water in beaker (glass) using finger method after washing, and answer questions on Activity Student Sheet. Finally discuss the findings.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Cunningham, William P. and Barbara Woodworth Saigo, Environmental Science: A Global Concern, Wm. C. Brown Publishers, Dubuque, IA, 1997.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

Roberts, Susan A. and S. K. Krishnaswaini, "Protecting the Source," Water Engineering and Management, Scranton Gillette Communication Inc., March 1982, p. 28.

Activities Harmful to Water Supply Reservoir

1. Unauthorized disposal of sludge, solid, septic and hazardous waste, dredge spoil
2. Erosion/sedimentation
3. Uncontrolled/illegal access
4. Atmospheric transfer of contaminants
5. Unauthorized/illegal impounding of upstream watercourses
6. Unauthorized use of pesticides
7. Accidental loss of hazardous materials from surface storage or transport
8. Discharges of animal wastes/agricultural runoff
9. Urban drainage
10. Point source discharges

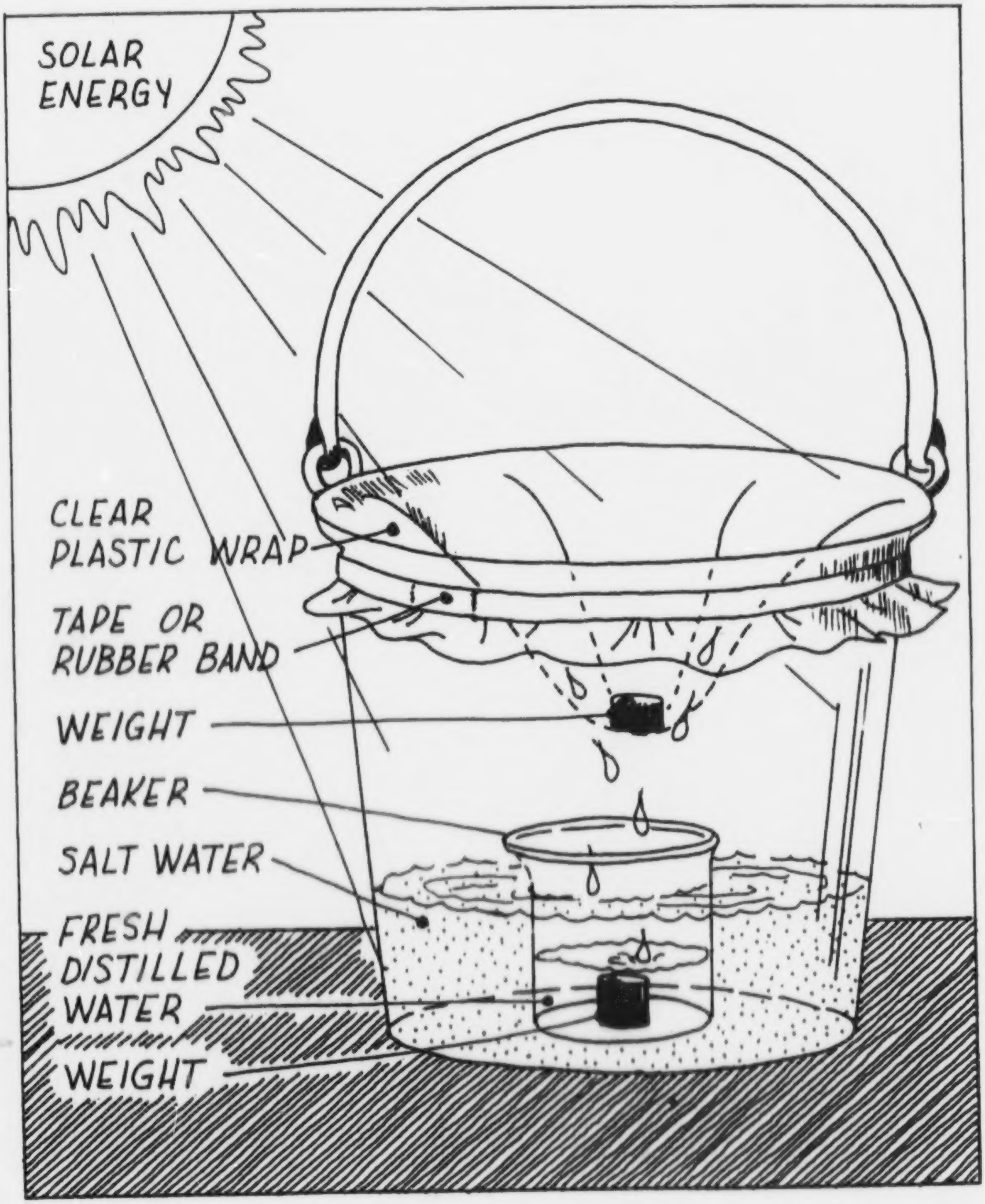
Constructing a Solar Evaporator or Solar Still

1. Follow the illustration to set up your lab materials. The water level should be at least an inch below the top of the beaker.
2. Be sure that your plastic completely covers the top bucket. The plastic should sag enough when the weight is placed on it so that a cone shape is formed that points down to the open beaker. Make sure that the plastic does not touch the mouth of the beaker.
3. Place your apparatus in the heat of the sun and leave it there for a few hours.
4. During class the next day, remove the plastic covering and taste the water in the beaker.

Results

1. How does it taste? _______________ Is it fresh or salty? ___________
2. What was the energy source that caused the water to change states? ____________________
____
____
3. What are the three states of water? ____
____
____

A SIMPLE SOLAR STILL


SOLAR ENERGY
CLEAR PLASTIC WRAP
TAPE OR RUBBER BAND
WEIGHT
BEAKER
SALT WATER
FRESH DISTILLED WATER
WEIGHT

Potential sources of surface water/groundwater contamination (based upon lists compiled by U.S. EPA and ADEM)

1. Gas stations/service stations
2. Truck terminals
3. Fuel oil distributors/storage
4. Oil pipelines
5. Auto repair shops
6. Body shops
7. Rustproofers
8. Auto chemical suppliers/wholesalers/retailers
9. Pesticide/herbicide/insecticide wholesalers/retailers
10. Small engine repair shops
11. Dry cleaners
12. Furniture strippers
13. Painters/finishers
14. Photographic processors
15. Printers
16. Automobile washers
17. Laundromats
18. Beauty salons
19. Medical/dental/veterinarian offices
20. Research laboratories
21. Food processors
22. Meat packers/slaughter houses
23. Concrete/asphalt/tar/coal companies
24. Treatment plant lagoons
25. On-site sewage
26. Railroad yards
27. Storm water impoundment
28. Cemeteries
29. Airport maintenance shops
30. Airport fueling areas
31. Airport firefighter training areas
32. Industrial manufacturers
33. Machine shops
34. Metal platers
35. Heat treaters/smelters/descalers
36. Wood preservers
37. Chemical reclamation sites

38. Boat builders/refinishers
39. Industrial waste disposal sites
40. Wastewater impoundment areas
41. Municipal wastewater treatment plants and land application areas
42. Landfills/dumps/transfer stations
43. Junk/salvage yards
44. Subdivisions
45. Individual residences
46. Heating oil storage (consumptive use) sites
47. Golf courses/parks/nurseries
48. Sand and gravel mining/other mining
49. Abandoned wells
50. Manure piles/other animal waste
51. Feed lots
52. Agricultural chemical spreading/spraying
53. Agricultural chemical storage sites
54. Construction sites
55. Transportation corridors
56. Fertilized fields/agricultural areas
57. Petroleum tank farms
58. Existing wells
59. Nonagricultural applicator sites
60. Sinkholes
61. Recharge areas of shallow and highly permeable aquifers
62. Injection wells
63. Drainage wells
64. Waste piles
65. Materials stockpiles
66. Animal burial
67. Open burning sites
68. Radioactive disposal sites
69. Saltwater intrusion
70. Mines and mine tailings
71. Other

SOURCE WATER PROTECTION:
Groundwater Sources

OBJECTIVES

The student will do the following:

1. Define a Wellhead Protection Program.
2. List 25 common groundwater pollutants.
3. List 25 potential sources of groundwater pollution.
4. Identify problems involved in starting a Wellhead Protection Program in a developed area.

SUBJECTS:
Social Studies (Economics, Government), Science (Physical, Ecology, Earth, Chemistry), Ethics

TIME:
1-2 class periods

MATERIALS:
copies of student sheets

BACKGROUND INFORMATION

It is important to be aware of the source of your drinking water. If the water is pumped from a well, the source is groundwater from an aquifer. Just like rivers and lakes, aquifers need to be protected from contamination. Chemicals spilled on or applied to the ground can move down and eventually contaminate an aquifer, sometimes making groundwater unsafe to drink. It is especially important to protect areas immediately around wells from releases of harmful chemicals, because it is from within these sensitive areas that chemicals can most quickly and profoundly affect the quality of water pumped from a well.

EPA's Source Water Protection (SWP) Program was established to help states and communities protect their drinking water supply sources. Wellhead Protection Programs may serve as Source Water Protection Programs for communities relying on groundwater as their source of drinking water. Wellhead protection is a 5-step process involving: (1) forming a community planning team; (2) delineating the area contributing groundwater to a water supply well; (3) identifying potential contaminant sources within the delineated area that pose threats to the well; (4) using a combination of management strategies to ensure that identified sources don't impact the well; and (5) developing a contingency plans in case there is a release of contaminants within the delineated area.

Wellhead protection management strategies incorporate broad concepts such as land use control and/or management, best management practices, and pollution prevention. Specific strategies may include the following: zoning controls, local ordinances governing pesticide/herbicide use,

Source: Water Sourcebook; Copies available by calling (770) 426-8936, Ext. 234
or visit www.griffin.peachnet.edu/waterwise/wwc.htm

enforcement of septic tank regulations, and community education. Homeowners, businesses, farmers, and industries may also be encouraged to use pollution prevention and best management practices to prevent contamination in the delineated areas. For example, waste oil collection centers may be set up in convenient locations so that oil can be brought in for proper disposal or recycling (rather than citizens dumping it illegally onto the ground).

The illustration in Figure 4 shows a wellhead protection area with the zone of influence (Zone I), a 10-year time-of-travel (Zone II), and the rest of the recharge area for the well (Zone III). Potential pollutants and potential pollutant sources are listed in Student Sheets, Figures 2 and 3 respectively. Various activities in the recharge area are illustrated in Figure 4.

Terms

Source Water Protection: process that involves delineating areas contributing water to a water well or surface water intake; identifying potential contaminant sources that may threaten the water supply; and using management strategies to protect the source water from contamination. Source water protection is applied to both surface water and groundwater supply sources.

time-of-travel: the time required for groundwater to move from a specific point beneath the surface to a well

Wellhead Protection Area: the surface and subsurface area surrounding a public water supply well through which contaminants are reasonably likely to move toward and reach such well

Wellhead Protection Program (WHPP): a groundwater-based source water protection program

zone of influence: area surrounding a pumping well within which the potentiometric surface has been changed due to groundwater withdrawal

zoning: to divide into areas determined by specific restrictions; any section or district in a city restricted by law for a particular use

ADVANCE PREPARATION

A. Copy Student Sheets for each group or individual.

B. Make overhead transparency of Student Sheets.

PROCEDURE

I. Setting the stage

  A. Discuss the concept of Wellhead Protection and go over terms.

  B. Put up overhead transparencies of Figure 1 and Figure 4.

    1. Discuss land use zones and time-of-travel.

    2. Discuss groundwater pollutants and potential sources. (Students may wish to read over Student Sheets - Figures 2 & 3.)

  C. Break into study/discussion groups to complete activities.

II. Activity

  A. Assume you are a mayor considering a WHPP. List the considerations (pros and cons) of establishing such a program.

  B. If you are a farmer or businessperson in the same town, what concerns would you have if this program were instituted?

  C. As a citizen drinking the water produced by the well, what concerns would you have? What form would you prefer the WHPP take? Why?

  D. You are an employee of the state environmental agency and would like to see a WHPP put into place by all small towns. What position would you take relative to this town after learning the above positions?

  E. Is a WHPP a good groundwater protection approach? Why or why not?

III. Follow-up

  A. Each group should have a spokesperson report its conclusions to the class. Allow some discussion and debate over the "best" policies.

  B. Give quiz over groundwater pollutants and potential sources of pollution to groundwater.

  C. Have students write a short essay about what they think they could do to protect groundwater in the area.

IV. Extensions

A. Students should find out if their state or city has a WHPP and what is or is not being done in its implementation.

B. Locate a city well and visit it. Have students identify pollutants and potential pollution sources in the wellhead protection area.

C. Learn about Environmental Ethics. Read "Jay's Situation" and "Ethics". Respond to the questions. Students should look for ethical, win-win compromise solutions.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Case Studies in Wellhead Protection, EPA Office of Water, EPA 440-6-90-004, April 1990.

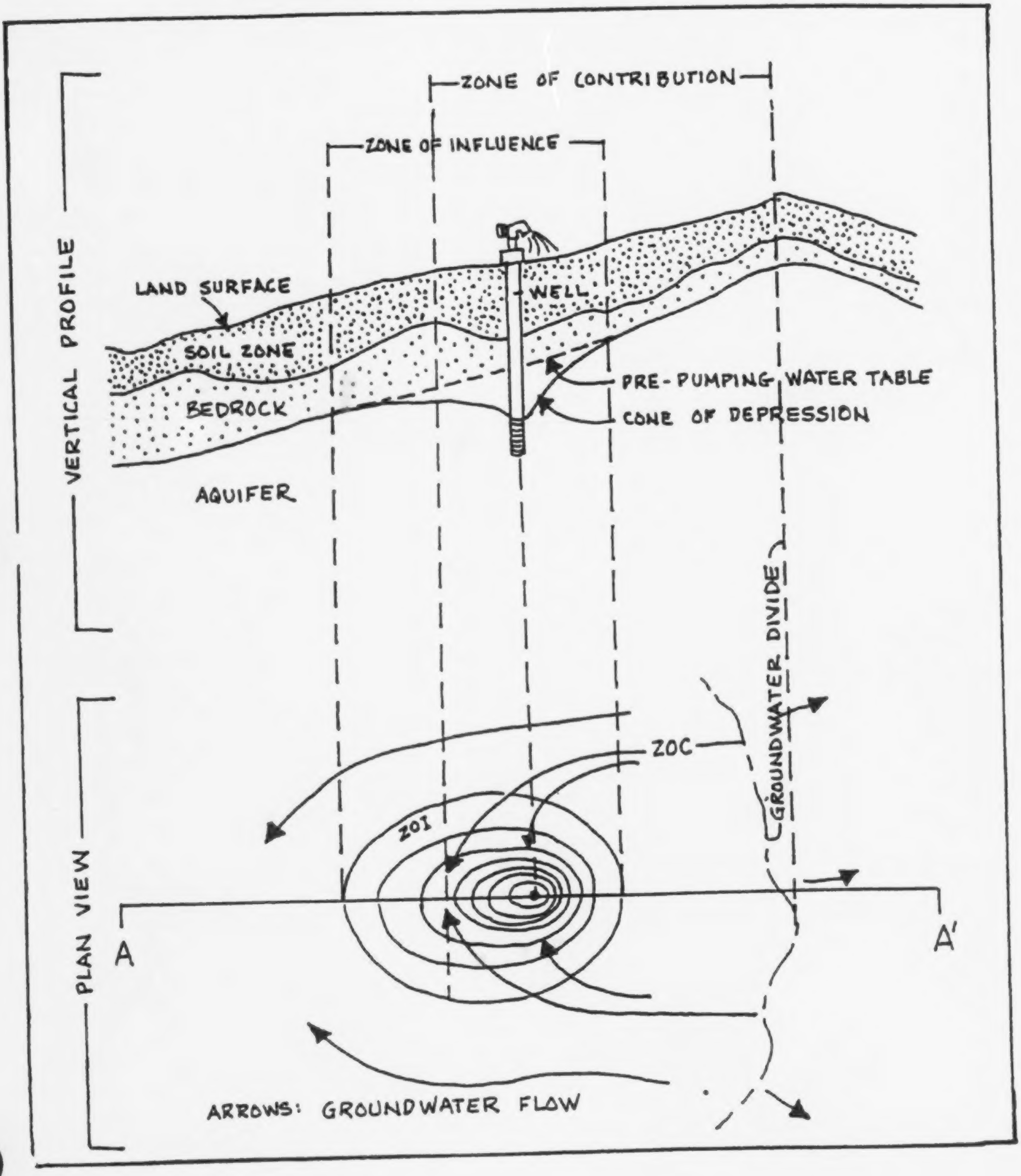
Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Cunningham, William P. and Barbara Woodworth Saigo, Environmental Science: A Global Concern, Wm. C. Brown Publishers, Dubuque, IA, 1997.

Enger, Eldon D. and Bradley F. Smith, Environmental Science: A Study of Interrelationships, 5th Edition, Wm. C. Brown Publishers, Dubuque, IA, 1983.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

DETERMINING A WELLHEAD AREA


ZONE OF CONTRIBUTION
ZONE OF INFLUENCE
VERTICAL PROFILE
LAND SURFACE
WELL
SOIL ZONE
BEDROCK
PRE-PUMPING WATER TABLE
CONE OF DEPRESSION
AQUIFER
GROUNDWATER DIVIDE
PLAN VIEW
ZOC
ZOI
A
A'
ARROWS: GROUNDWATER FLOW

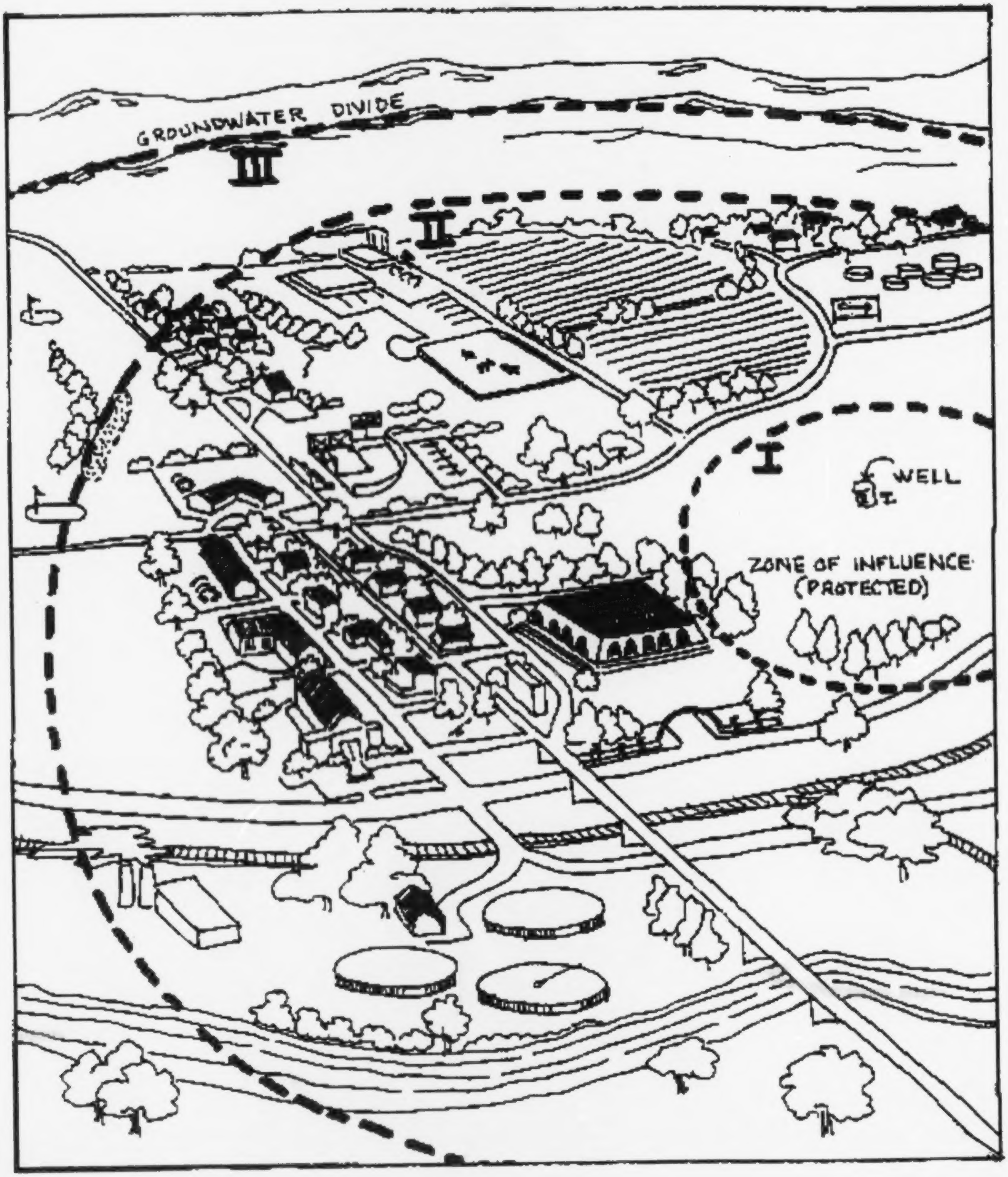
COMMON GROUNDWATER POLLUTANTS
FIGURE 2

1. Antifreeze (for gasoline coolant system)
2. Automatic transmission fluid
3. Engine and radiator flushes
4. Hydraulic fluid (including brake fluid)
5. Motor oils/waste fuels/grease lubricants
6. Gasoline, jet fuel
7. Diesel fuel, kerosene, #2 heating oil
8. Degreasers for driveways and garages
9. Battery acid (electrolyte)
10. Rust proofers
11. Car wash detergents, waxes, and polishes
12. Asphalt and roofing tar
13. Paints, lacquer thinners, and brush cleaners
14. Floor and furniture strippers
15. Metal polishes
16. Laundry soil and stain removers (including bleach)
17. Spot removers, cleaning solvents
18. Disinfectants
9. Household cleaners (oven, drain, toilet)
20. Cesspool cleaners
21. Road salt (Halite)
21. Refrigerants
22. Pesticides (insecticides, herbicides, rodenticides)
23. Photochemicals/ Printing ink
24. Wood preservative (creosote)
25. Swimming pool chlorine or bromine compounds
26. Lye or caustic soda
27. Jewelry cleaners
28. Leather dyes
29. Fertilizers (if stored outdoors)
30. PCBs
31. Other chlorinated hydrocarbons, including carbon tetrachloride)
32. Any other product with "Poison" labels (including chloroform, formaldehyde, hydrochloric acid, and other acids)
33. Other products not listed that you feel may be toxic or hazardous (please list):

POTENTIAL SOURCES OF GROUNDWATER POLLUTION
FIGURE 3

1. Truck terminals and service stations
2. Petroleum pipelines, stores, and tank farms
3. Auto repair, body shop, and auto supplies
4. Rust proofers
5. Pesticide, herbicide wholesalers and
6. Dry cleaners
7. Painters, finishers, furniture strippers
8. Printers, photo processors
9. Auto washes, laundromats
10. Beauty salons
11. Medical, dental, and vet offices
12. Food processors, meat packers, and slaughter houses
13. Concrete, asphalt, tar, and coal companies
14. On-site sewage disposal
15. Railroad yards, industrial sites
16. Storm water impoundment
17. Cemeteries
18. Airport maintenance, fueling
19. Machine shops
20. Metal platers
21. Heat treaters, smelters, annealers, descalers
22. Wood preservers
23. Chemical reclamation
24. Industrial waste disposal
25. Municipal and private waste retailers wastewater treatment plants, lagoons
26. Landfills, dumps, and transfer stations
27. Junk, salvage yards, recycle centers
28. Subdivisions, individual residences
29. Heating oil storage (consumptive use)
30. Golf courses, parks, nurseries
31. Sand, gravel, other mining
32. Abandoned wells, existing wells, sinkholes
33. Feed lots, manure piles
34. Agricultural chemical storage, handling, spreading, spraying
35. Construction sites
36. Transportation corridors
37. Fertilized fields, agricultural area

WELLHEAD PROTECTION


GROUNDWATER DIVIDE
III
II
I
WELL
ZONE OF INFLUENCE
(PROTECTED)

JAY'S SITUATION

Jay Barlow is sitting with his elbows on his desk. His face is pressed into his hands. He feels a small hand pull his hand away from his face. "Daddy?" Jay looks down into his daughter's sparkling brown eyes. He is still her hero, and that trusting smile just increases the pressure he already felt.

Last week Jay was on top of the world. He was hired onto an environmental project as a consultant. The state of Florida had finally passed a regulation that would require a zone of protection around wellheads. The state's minimum requirement is a 500-ft. radius around the well. The suburb he lives in has adopted more stringent measures. He was given a map showing several public wells from which drinking water is pumped. His task is to recommend a viable zone of protection and report any potential contamination hazards.

Interestingly, the very area in which he lives is included on the map. He is familiar with a large land development that has been in construction for two years. His neighbor has told him many details as he is the construction foreman. The massive construction effort has provided 200 jobs. Jay decides to meet with a company representative. They discuss the scope of the project. To his dismay, he discovers that the final two years of the company's project involve developing land directly over the aquifer within the state's minimum protection zone from the well.

The land developers purchased the land at high cost before the state laws were passed. The company has invested millions in pre-development and will not respond positively to any attempt to block the contract. They have plenty of resources to fight a legal battle against the state.

Jay's uncle calls him for advice on a leaking UST (underground storage tank). He thought to call Jay because Jay knows about environmental issues. His uncle cannot afford to have the tank dug up and replaced; it would bankrupt his small business. Jay has no idea what to tell his uncle except that the leaking gasoline is a serious threat to groundwater. Jay's uncle laments that he has owned the station for 30 years and would have no income without it. As if Jay didn't have enough to think about, he realizes that his uncle's gas station is also located above the aquifer.

1. What do you think is Jay's primary responsibility as an environmental professional?

2. Does Jay have a responsibility to his uncle?

3. Are the construction workers Jay's problem?

4. Should he be worrying about the drinking water in his own region?

5. Should the above concerns affect Jay's recommendations to the state about the wellhead protection for that particular aquifer? If so, in what way?

ETHICS

As part of this lesson, the instructor may wish to include a brief discussion on ethics. The environmental industry is dependent on ethical decision making. For an intensive treatment of this issue, Michael Josephson's *Making Ethical Decisions* (1993) is perfect. In *Making Ethical Decisions*, Josephson describes "The Six Pillars of Character: (1) Trustworthiness, (2) Respect, (3) Responsibility, (4) Justice and Fairness, (5) Caring, (6) Civic Virtue and Citizenship."[1]

Most students of this age will be surprised to learn that acting with "Caring" (being sensitive to human suffering such as job loss and family distress) is an integral part of the decision-making process at the professional level. The teacher will most likely find that the majority of the class will choose extreme action in one direction or the other. The middle road seems a taboo place to choose; yet, in reality, it is often the only reasonable one. With the added responsibility of ethics, students will find achieving that "balance" between the economy and environment a less bitter pill to swallow.

It may be most effective for the ethics treatment to follow the exercise. Since the "balance" method gives them a standard to shoot for, students should then have the opportunity to reconsider their answers.

Here is a closure to share with students after they have completed the activity.

Reality will be frustrating for the generation who has grown up learning to accept environmental responsibility. The following recount is simplified, but factual, and is a real life example of the middle road. It should not be discouraging but enlightening. Sometimes when it is impossible to kill the dragon, be satisfied with knocking a chink out of its armor.... progress is progress is progress!

---

[1] Josephson, Michael, *"Making Ethical Decisions in Environmental Practice,"* Environmental Manager, Vol. 1, July 1993.

CONCLUSION

There are many different options that Jay might choose. He always has the option of consulting with other professionals if he has run into an ethical snag. Generally, they will be objective and a good source for ideas.

In dealing with land development, companies have to comply with many regulations today and often have a representative or department that handles that aspect. Jay may opt to call a meeting with this individual or group of individuals and call attention to the aquifer's vulnerability. Accomplished in a non-accusing diplomatic way, he may be able to convince the developers to choose double-walled, lined, or anodized septic tanks in order to head off future liability. While the threat to the aquifer is still apparent, it can be greatly reduced. The state may even be able to buy back a portion of the land. However, it is doubtful that the company would relent their construction. In fact, Jay may have to recommend a compromise or advise the department that they will probably be sued.

Jay's uncle may have some help in dealing with his gasoline leaks. If he is in compliance with other state and federal regulations for underground storage tanks, he may be eligible to receive assistance from Florida's leaking UST trust fund. Available in most states, these funds allow small business owners of USTs to receive assistance in cleaning up leaks. The money for these funds usually comes from a tax on gasoline. The sites chosen to receive cleanup funds are based upon how large the risk is to human health or the environment. Since Jay's uncle's tank is located in an area above a drinking water aquifer, there is a good chance that his cleanup will be funded.

In Florida, as previously discussed, there is a tremendous need for wellhead protection. In 1980, the Florida Department of Environmental Protection (FDEP) began fighting for wellhead protection. FDEP was promptly sued by large industrial corporations that had almost unlimited legal resources. The suit was in court for almost 15 years. FDEP was forced to accept a compromise, a middle-of-the-road decision, by the judge. They achieved the stipulation of a circular buffer zone 500 feet in diameter.

Of course, this circular zone has no basis either geologically or hydrologically. Most aquifers are oddly shaped and miles in length or width. FDEP officials wanted to model individual aquifers and tailor the needed buffer zones. What good does it do to have a 500-foot circle of protective zone and a five-mile long cigar-shaped aquifer? It seems nonsensical, but the FDEP rejoiced. They now have buffer zones. Before May 1994, they had none. Perhaps they should have agreed to a compromise years earlier and started gathering data for the next fight.

Even state environmental agencies understand that they cannot unduly restrict the state's or nation's economy. An unhealthy economy often creates an inadequate tax base, which can ultimately result in underfunded state agencies.

BLUE THUMB

Give drinking water a hand

TEACHER'S GUIDE

How Clean is Clean?

Introduction

As recently as 20 years ago, the standards for "clean" were based on aesthetic factors such as taste, odor and color. Today, we know that there are many things which we can't taste, smell or see that can still be harmful to us. For this reason, standards for what is "safe" or "clean" have been set by the government. This activity is designed to allow students to experience how difficult it is to "clean" an aquifer once it has become polluted by simulating hazardous material accidents which contaminate their aquifers (sponges).

Objective

Students will investigate how pollutants contaminate ground water by using a simple model of an aquifer.

General Procedures

1. Each group will need a large cellulose household sponge, 3 - 16 oz. clear plastic cups, a paper or foam dinner plate and a tray or bucket to collect water squeezed from their sponges. Make several copies of the Student Activity Sheet on the reverse side of this sheet. The class will also need the following three liquids to represent the pollutants in the different accident scenarios for each Group:

Group 1	1 ounce of Liquid soap
Group 2	1 ounce of Salad oil (If small graduated cylinders are available use 20 mL of oil)
Group 3	1 ounce of Gelatin (dissolve a package in hot water just before class)
Group 4	1 ounce of an equal mixture of soap, oil and gelatin

2. Before class pour each "pollutant" in a separate small paper cup. Locate each group's materials near its work station or let students collect materials and take them to their work stations.

3. Divide the class into four random groups, each with four or five students. If more groups are needed, make extras of groups 1 and 3, to minimize clean up problems. Pass out the Student Activity Sheets to each group and direct them to begin collecting the materials as described in Step 1 of the activity. Those not directly involved in squeezing sponges should be assigned duties such as predicting how many rinses it will take for the sponges will become clean, emptying the cups between squeezes, recording the number of squeezes, deciding when their group's sponge is clean, and whether it would be safe to drink the water that has been squeezed from the sponge.

4. After the students have finished the preparations in Step 1, read over the introduction on the Student Activity Sheet as a class. Be sure each group understands that the mixture in the small paper cup represents a "pollutant" released in the accident described for each group on their Activity Sheet.

5. Each group should repeat Steps 3 - 6 on their Activity Sheet until they either decide that the sponge is clean, or estimate how long it would take to clean the sponge or judge whether the sponge can be cleaned at all. If they haven't cleaned the sponge within 10 minutes, it may be best to let them make an estimate.

(NOTE: If possible, provide Group 2 with graduated cylinders. Have them pour each cup of rinse water into the cylinder and try to measure the volume of the oil layer in each rinse after the oil separates out.)

6. After all groups have recorded the number of rinses (actual or estimated) needed to clean the sponge, have them clean up their work stations and return their materials.

Discussion

Have each group report their results to the rest of the class. As they give their report, ask the following questions:

1. Could they get the water clean?
2. Describe how easy or difficult it was to remove the pollutant from the sponge. Once the sponge was contaminated with 1 ounces of a pollutant, how many more ounces of water were needed to clean the sponge?
3. If Group 2 used graduated cylinders, ask them how much oil was recovered from the sponge. Will all of the oil ever come out of the sponge?
4. How could they tell it was clean? If they cannot see any pollutant, does that mean it's not there?
5. What reasons can the class give as to why some pollutants might be easier to clean up than others?
6. For group 4, which pollutant in their mixture would clean up first, based on what the other groups found?

STUDENT ACTIVITY SHEET

How Clean Is Clean?

Introduction

In comparison with rivers or streams, water in the ground moves very slowly and very calmly in rivers that are very wide - sometimes more than one hundred miles wide. These slow underground rivers are called aquifers. Many of us get our drinking water from aquifers. When a pollutant is spilled on the ground, it slowly seeps down and can get into an aquifer, making our water unsafe to drink. When our aquifer gets polluted, we need to get answers to many difficult questions like how toxic are the pollutants?, how fast are the pollutants moving in the aquifer?, and how difficult are they to remove from the aquifer?

In this activity, the class is divided into at least 4 groups. Each group will experiment with a different kind of pollutant to find out how difficult it is to remove the pollutant from a sponge. Aquifers are not really spongy, but we can still use a sponge to give us some idea of what happens when an aquifer gets contaminated.

Group 1 will use soap as its pollutant. In this case, the ground is contaminated when a tanker truck gets into an accident on the highway and spills the pollutant on the side of the road. The soap is a lot like real pollutants which dissolve in water but are not hazardous or toxic.

Group 2 will use salad as its pollutant. Again, a truck accident has caused the spill as for Group 1's pollutant. The oil is a lot like gasoline which is hazardous and toxic, but does not mix well with water.

Group 3 will use gelatin as its pollutant. This time the pollutant has leaked into the ground from a large old and rusty underground tank where it has been stored for years. The gelatin is a lot like pesticides which dissolve in water and are toxic.

Group 4 will have the worst troubles. An explosion has occurred at a major chemical plant, and all three types of pollutants - soap, oil and gelatin - have been spilled onto the ground.

Objective

You will investigate how pollutants contaminate an aquifer by using a sponge as a simple model of an aquifer.

General Procedures

1. One student in each group should pre-moisten their sponge by soaking it in water, then squeezing it until it is just moist to touch. Other students in each group should be sure they have the following items at their work station:

   One large cup of clean water
   Two empty large cups
   Tray or bucket for collecting rinse water
   One paper or plastic dinner plate
   Small cup containing a "pollutant"

   After these materials have been collected, wait for the teacher to read over the Introduction with the class.

2. Place the sponge on the plate and pour the liquid "pollutant" in the small cup onto the sponge, letting the sponge soak up as much pollutant as possible.

3. SLOWLY pour clean water onto sponge, letting it soak in until the sponge is full. Pour back into the cup any excess water on the plate. You will need to know how many cupfuls of water are being used to rinse the sponge, so keep track of all the water you use.

4. Lift the sponge and squeeze it out completely, catching the water in an empty large cup.

5. Pour more water onto the sponge, letting it soak in.

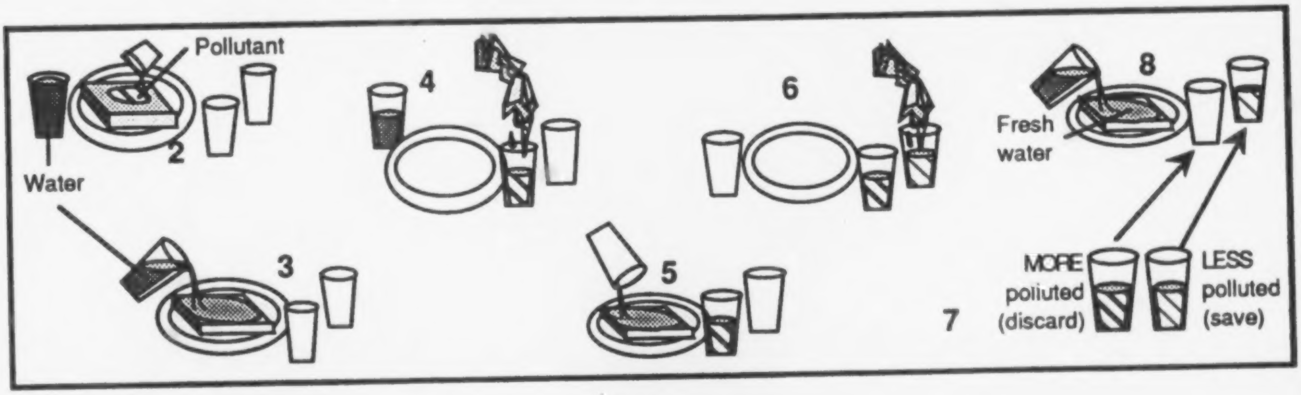
6. Squeeze out the sponge again, this time using the other empty large cup to catch the water squeezed from the sponge.

7. Compare the two cups of polluted water. Decide which cup seems to have the most polluted water, then empty this cup. Set aside the cup containing the water which looks less polluted.

8. Repeat Steps 5, 6 and 7 each time comparing the water in the two cups to decide whether the water is getting cleaner each time the polluted sponge is rinsed out. Count the number of times the sponge is rinsed.

9. Estimate to the nearest 1/4 cup, how many cupfuls of water were used to rinse the sponge. Convert to ounces (One cupful equals 16 ounces). How much more rinsing - if any - must be done before the water squeezed from the sponge would be "safe" to drink?

10. After you have finished the experiment, return materials to the proper place, then get ready to report your results to the class.



Give drinking water a hand

TEACHER'S GUIDE

Tracking Pollution - A Hazardous Whodunnit

Introduction

This activity presents the student with a real world problem and provides a simple, but not always accurate tool for investigating the problem.

The problem is that a town's drinking water is contaminated In many small towns like Riverville, every home and most businesses have a private well. Lab results from several wells showed that the ground water has been contaminated with a kind of fuel stored by three companies. Of the three possible suspected sources of contamination, each suspect has a reasonable argument as to why they are not responsible for the problem:

1. The Heating Oil Company is the prime suspect since they store the most fuel and sell it to the other two suspected companies.
2. The Heating Oil Co. has just tested their tanks and knows they are safe. They argue that the Trucking Company is the source of pollution.
3. The Trucking Co. says the source could just as likely be the Heating Oil Co. or the Gas Station. They claim there is no proof that they are responsible.

The only way to find out who is responsible is to produce some evidence to help decide which of these is the actual source of contamination. Emphasizing the expense of cleaning up ground water contamination and the need for certainty before forcing a business to begin cleaning up lets the student know that there is often a lot at stake in this kind of investigation.

Objective

Students will make a topographic map, use it to predict ground water flow and investigate the most likely source of ground water contamination.

General Procedures

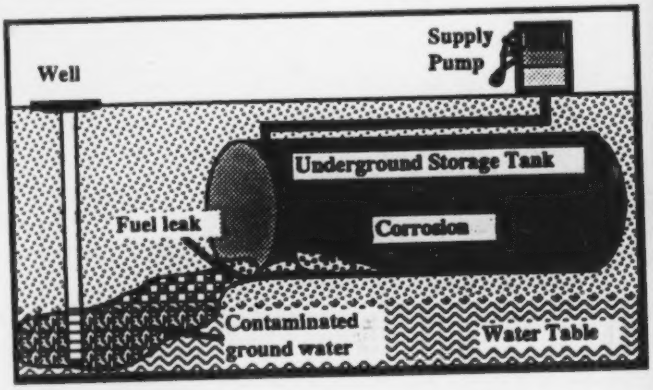
1. It will be best for students to work together in groups of at least two. Each group will need:

   a medium sized rubber band about 1/8 inch in width

   a ruler, pencil and pen

   Student activity sheet

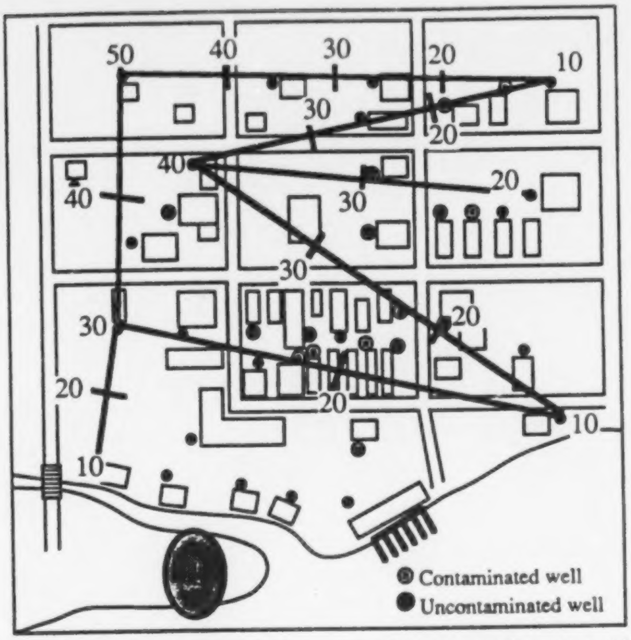
2. Read over with the class the Introduction on the Student Activity Sheet. Ask them which of the three they think is the actual source and have them write down their best guess.



3. You might also explore whether anyone can think of any simpler ways of finding out the source of contamination than by doing this activity. Point out the fact that another way of finding out whodunnit is to test the contaminated wells again to find out which wells have more contaminant in the water. The wells nearest the source should have the highest levels; those farthest from the source will be lower. This can be expensive though, since lab tests are between $100 to $200 apiece.

4. The contours of a landscape can be estimated even if the elevation is known for only a few points, provided the points are well scattered around the area. The procedure used here assumes a constant slope between these known points. If one point is at 10 ft. above sea level and another point is at 50 ft., then when the distance between the points is divided into four equal segments, the elevation will increase 10 ft. over the length of one segment. This process is described in more detail on the next page.

5. The rubber band is used to divide lines into equal segments, depending on the difference in elevations of the endpoints of the line. This process of dividing the lines can be very tedious if done mathematically, and diverts from the point of the activity. Using the rubberband method simplifies the process considerably. Cut the rubber band open and lay it out flat, without stretching it, along the edge of a ruler. With a pen, make at least five marks 1/2 inches apart beginning from about the middle of the band. Step 6 on the next page describes how to use it to divide a line.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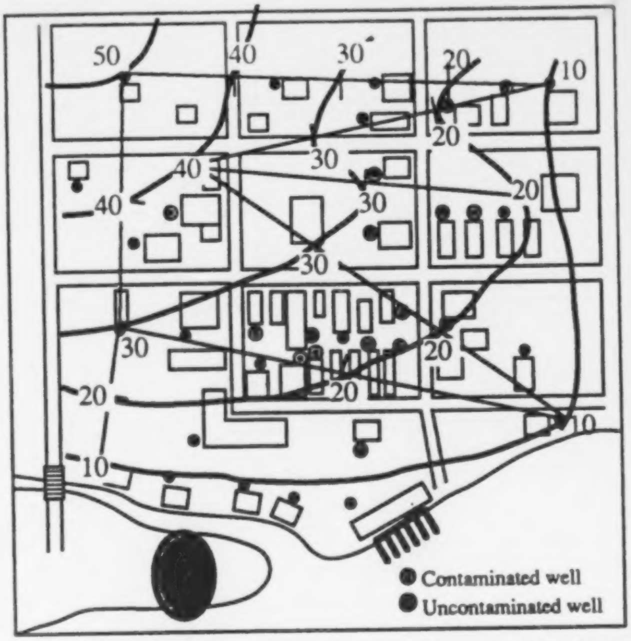
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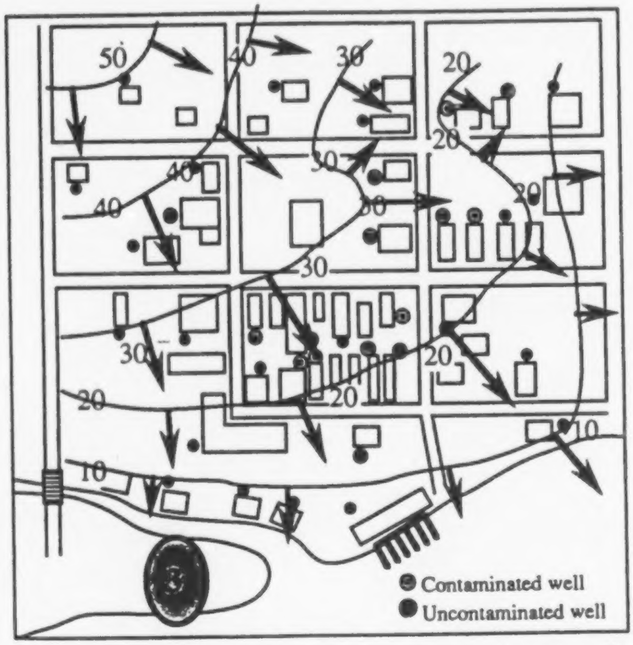
6. LIGHTLY, with pencil, draw lines between each well and its nearest neighbors having at least a 20 foot difference in elevation. To divide these lines into equal segments representing 10 ft. increases in elevation, stretch the marked rubber band so that a mark is over each well at the line's endpoints, with the necessary number of marks between to allow you to count up by tens from one well to the next. For example, a line between the two wells at 10 and 40 ft. needs two marks between the wells. Stretch the band so that a mark falls at each endpoint on the line and two marks lie between the endpoints. Make marks on the line at each of the two intervening marks on the stretched band. Label these marks 20 and 30 ft. Repeat for each line.

7. LIGHTLY draw smooth curved lines connecting all wells and marks having the same elevations. These are contour lines.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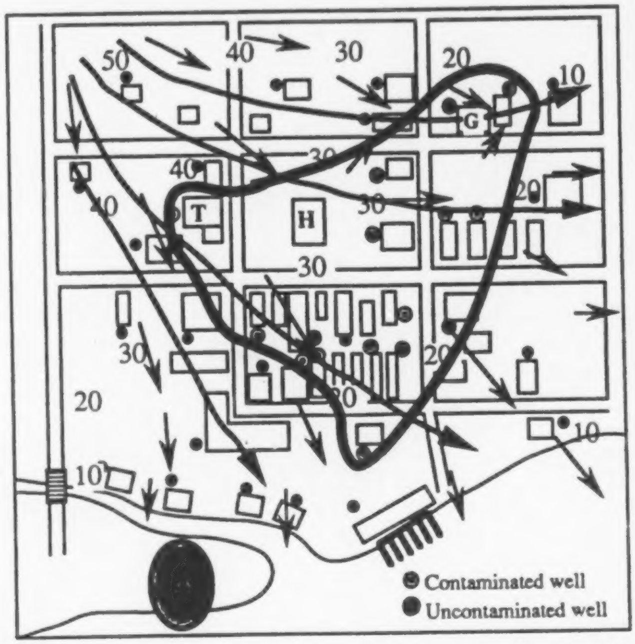
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8. Using a PEN, every half inch or so along each contour line, draw short arrows outward perpendicularly from one contour line to the contour line having the next lowest elevation. It is important that these arrows be as perpendicular as possible to give the best estimate of the direction of ground water flow. Erase the contour lines and other pencilled-in lines to make the map less confusing. To get a better sense of overall direction of flow, you might want to draw a few longer arrows which average out the shorter ones.

9. Draw a loop that groups together all of the contaminated wells. From the flow arrows, note that the plume has spread in two directions, to the top right corner and to the lower left. It should be clear that the Trucking Co. (T) is the source of pollution. Also, the uncontaminated well found within the cluster of contaminated wells is a newer, deep well which taps an aquifer protected by an underground layer of dense rock (shale) which keeps fuel out. This may serve as a lead-in to the Resource Management Activity.

BLUE THUMB

Give drinking water a hand.

STUDENT ACTIVITY SHEET

Tracking Pollution - A Hazardous Whodunnit

Introduction

Riverville is a fictional town with a real problem. Each week, more citizens are complaining that their drinking water tastes bad. In many small towns like this one, there is no central water supply. Every home and most businesses have a private well. The town's mayor tested the water from several wells and found that the ground water has been contaminated with some kind of fuel. The wells that have been contaminated are marked out on the map on back of this page.

The mayor thinks the Heating Oil Company is responsible for this contamination and wants them to start investigating their fuel storage tanks which are buried underground and to check the tanks for leaks. The Heating Oil Co. says they just tested their tanks and knows they are safe. They think the Trucking Company is the source of pollution. The Trucking Co. says the source could just as likely be the Heating Oil Co. or the Gas Station, since all three places have underground tanks for storing the same kind of fuel.

So Riverville has a problem and no one is sure who is responsible. The mayor needs some way of proving who is causing the pollution and who should clean it up. **You will be the "detective" who helps prove where the pollutant is coming from.**

Cleaning up ground water contamination is a very expensive job. You should be very sure of the place you choose to start cleaning up, otherwise the money will be wasted. It is up to you to solve the mystery.

Objective

You will make a topographic map, use it to predict ground water flow and investigate the most likely source of ground water contamination.

General Procedures

To decide which of the suspected businesses is the most likely source of contamination, the easiest thing you can do is find out the direction that ground water flows. Since ground water generally flows downhill, following the slope of the surface of the land, you can be fairly certain that the suspected source which is farthest "upstream" is the real source of contamination.

This activity shows you how to estimate ground water flow by making a **contour** map. As in many very small towns, only a few people in Riverville know the exact **elevation** above sea level for their property. To make a contour map, it usually helps to know the elevations of as many places as possible. But this simple procedure can be used even though you only know a few elevations.

The map on back shows the elevations for seven wells and gives directions for drawing in the contours of the land. After you have finished this procedure, answer the questions below.

Questions

1. If the flow of ground water and the pollutants in it follow the contour of the land, what is the most likely source of the contamination, the Heating Oil Co., the Trucking Co. or the Gas Station?

2. The contamination plume will continue to spread slowly through the ground, much like smoke from a chimney drifting with the wind. Describe where on your map you think the plume will move with time.

3. Which of the uncontaminated wells do you expect to become contaminated in the near future? Do you think the school's water well will be contaminated?

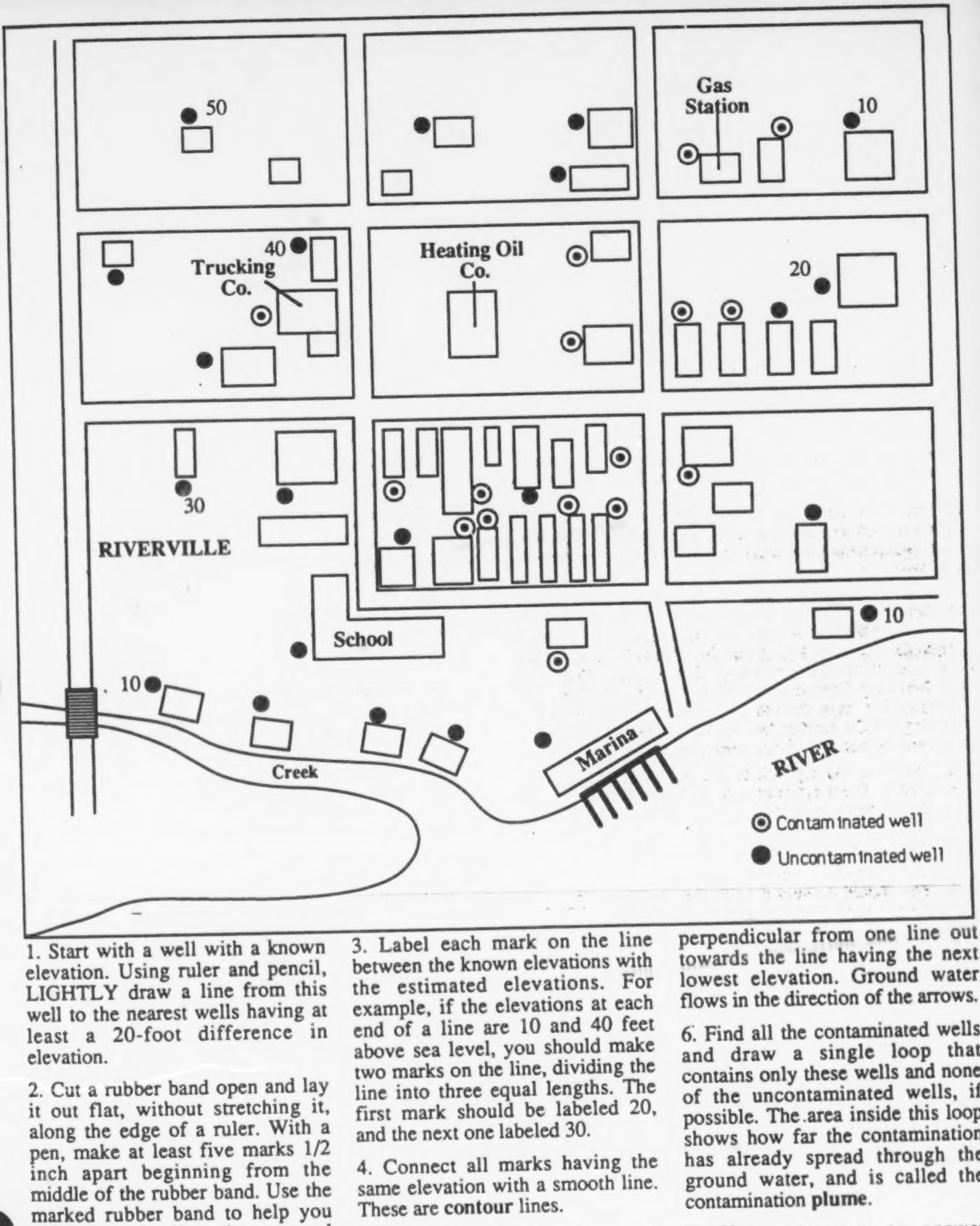
4. How do you explain the fact that one well within the plume was not contaminated? Give at least two possible reasons how this could happen. (Hint: see the Resource Management Activity)

5. Is it possible you are wrong in assuming that ground water flow follows the contour of the land? What else could you investigate to be sure?

6. Assuming that ground water flow does follow the contours of the land, is it possible that there are two sources of contamination? What would you expect to find if all three companies had leaking storage tanks and were actual sources of contamination?

Extensions

1. Get a map of your own community and use it to chart out ground water direction. Locate the community's water supply and any potential sources of contamination. What kind of precautions should be taken to keep an eye on potential sources of contamination?



1. Start with a well with a known elevation. Using ruler and pencil, LIGHTLY draw a line from this well to the nearest wells having at least a 20-foot difference in elevation.

2. Cut a rubber band open and lay it out flat, without stretching it, along the edge of a ruler. With a pen, make at least five marks 1/2 inch apart beginning from the middle of the rubber band. Use the marked rubber band to help you divide each line into equal segments. Your teacher will show you how this is done.

3. Label each mark on the line between the known elevations with the estimated elevations. For example, if the elevations at each end of a line are 10 and 40 feet above sea level, you should make two marks on the line, dividing the line into three equal lengths. The first mark should be labeled 20, and the next one labeled 30.

4. Connect all marks having the same elevation with a smooth line. These are **contour** lines.

5. Every half inch or so along each contour line, draw a short arrow perpendicular from one line out towards the line having the next lowest elevation. Ground water flows in the direction of the arrows.

6. Find all the contaminated wells and draw a single loop that contains only these wells and none of the uncontaminated wells, if possible. The area inside this loop shows how far the contamination has already spread through the ground water, and is called the contamination **plume**.

7. Use your map to answer questions on page 1.

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BLUE THUMB

Give drinking water a hand.

STUDENT ACTIVITY SHEET

Resource Management - Protecting your Drinking Water

Introduction

In almost any town, a large variety of chemicals and wastes are used or disposed of in day-to-day life. We are now learning that if things like gasoline, road salt, pesticides or sewage are not used or discarded wisely, they can contaminate a town's water supply.

We are also learning that some sources of water are easier to contaminate than other sources. Whether or not your town's supply is ***vulnerable*** to contamination depends on many different factors. These factors may add together to protect the supply, or to leave it very vulnerable to contamination.

To estimate the vulnerability of the ground water flowing under an area of land, a *hydrogeologist* measures several factors which affect how quickly rain water moves through the ground in that area. Pollutants will usually move in the same way as rain water.

Once you know something about each of these factors, you will be able to decide what must be done to be sure your drinking water will always be safe.

Objective

In this activity, you will use a simple mathematical model of *ground water vulnerability* to estimate the vulnerability of a small town's water supply.

Table 1
Estimated value of five factors affecting groundwater vulnerability

FACTOR	VALUE	
1. **Yearly rainfall** (total amount of rain that falls in one year)	3	... if more than 40 in.
	2	... if from 15 to 40 in.
	1	... if less than 15 in.
2. **Depth to water** (vertical depth from surface to aquifer)	3	... if less than 10 ft.
	2	... if from 10 to 75 ft.
	1	... if greater than 75 ft.
3. **Aquifer type** (Type of soil/rock aquifer passes through)	3	... if sand or gravel
	2	... if limestone
	1	... if bedrock
4. **Soil type** (Main type of soil and rock above the aquifer)	4	... if sand or gravel
	3	... if limestone
	2	... if loam or silt
	1	... if clay or shale
5. **Lay of the land** (The general slope of surface of the land)	3	... if flat
	2	... if gently rolling hills
	1	... if steep hills/mountains

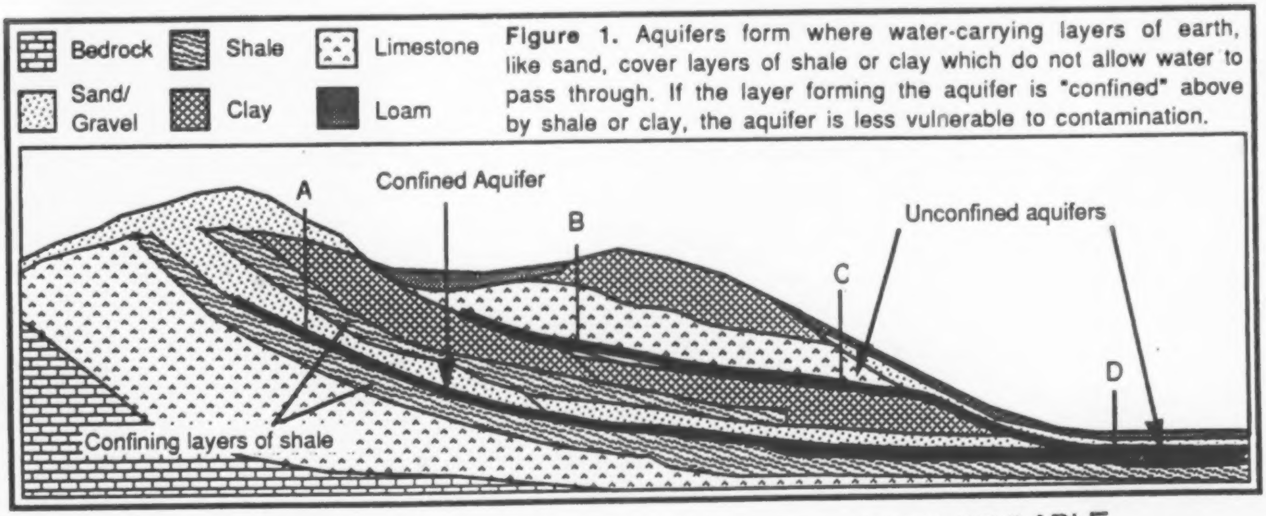

Figure 1. Aquifers form where water-carrying layers of earth, like sand, cover layers of shale or clay which do not allow water to pass through. If the layer forming the aquifer is "confined" above by shale or clay, the aquifer is less vulnerable to contamination.

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Model of ground water vulnerability
There are many factors affecting the vulnerability of a water supply, but we will only look at the five factors described in Table 1. A value of 1 means it is harder for rain water (and pollutants) to reach the supply, while a value of 3 means it is easier. It may be easy to see that the greater the depth to water, the longer it will take rain water to reach the supply. But how does a steep slope make the area less vulnerable? Figure 1 shows how some of these factors affect the vulnerability of various aquifers.

Table 2

Directions: Use Table 1 to find out how many points should be given for each of the five factors.

For example, **Table 1** tells you that if the depth to water is less than 15 ft, you should give 3 points for this factor in Quadrant 1. Values from Table 1 may be averaged.

Fill in the rest of the blanks for each factor, then add them up to find the vulnerability of each quadrant.

- **Quadrant 1**

Depth to water	12ft	3
Yearly rainfall	45"	___
Aquifer type	Sand/gravel	___
Soil type	Loam/sand	___
Lay of land	Flat	
	VULNERABILITY SCORE	___

- **Quadrant 2**

Depth to water	40ft	___
Yearly rainfall	45"	___
Aquifer type	Limestone	___
Soil type	Limestone/loam	___
Lay of land	Gentle slope	
	VULNERABILITY SCORE	___

- **Quadrant 3**

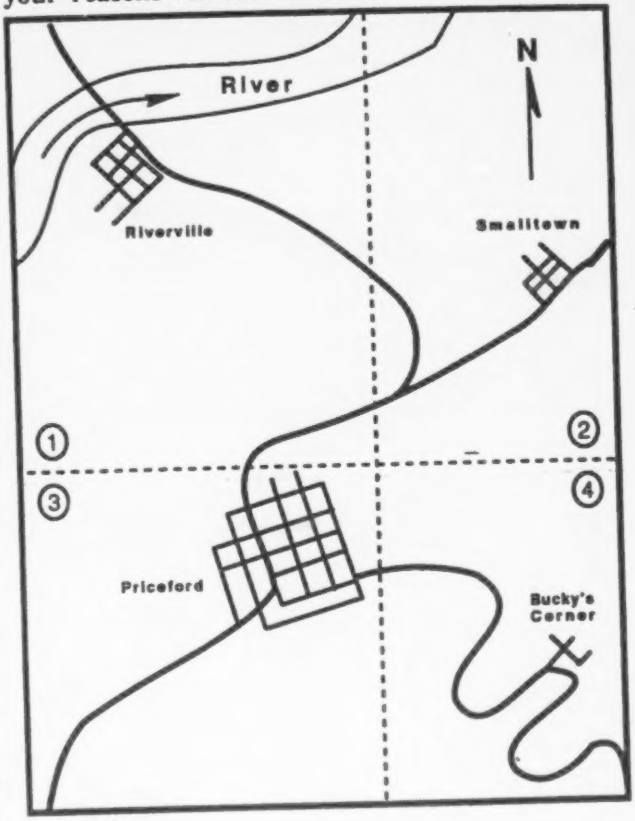
Depth to water	60ft	___
Yearly rainfall	38"	___
Aquifer type	Limestone	___
Soil type	Limestone/clay	___
Lay of land	Rolling hills	
	VULNERABILITY SCORE	___

- **Quadrant 4**

Depth to water	100ft	___
Yearly rainfall	34"	___
Aquifer type	Sand/gravel	___
Soil type	Shale/clay	___
Lay of land	Steep hills	
	VULNERABILITY SCORE	___

How to use the model
You can get a rough idea of the vulnerability of the underlying aquifer in each of Priceford's four quadrants by using these five factors to give each quadrant a "score" on how easy it would be for a pollutant to pass through the ground to contaminate the aquifer.

Follow the instructions for filling out Table 2. Then use your results along with the map of the Priceford area to answer the questions at the bottom of the page. **Give your reasons for each answer!**



Questions.

1. Discuss how Factors 2-5 described in Table 1 affect the vulnerability of water supplies at Points B, C and D in Figure 1. If three towns get their water supplies at Points B, C and D, which supply would be the most vulnerable? The least vulnerable?

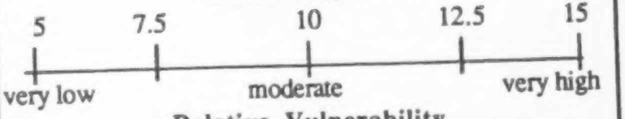
2. Use Table 3 below to interpret the vulnerability scores you calculated in Table 2. Which town's water supply would be most likely to be contaminated if a larger tanker truck full of a toxic chemical spilled its contents during a traffic accident on the nearest road?

3. Compare the vulnerability values you calculated in the four towns in the above map to Points A, B, C and D in Figure 1. Which of these towns is most likely to be located at which of these Points?

4. How would one town's pollutants affect the other town's supplies? If a wood preserving chemical is found in Smalltown's water, but not in Riverville's, where is the most likely area where the source of contamination might be found?

Table 3.

Vulnerability Score



Relative Vulnerability

Give drinking water a hand.

STUDENT

ACTIVITY

SHEET

Decision Making - A Mock Town Meeting On A Proposed Tank Farm

Suggested Prerequisite: Resource Management Activity

Introduction

Your class will represent all of the citizens who live and work in a small town called Priceford. A major business development company called Zanec Corporation, has asked Priceford for permission to install five 10,000 gallon Underground Storage Tanks (USTs) on their property just outside of Priceford.

This proposed tank farm will supply fuel and manufacturing chemicals to an existing Ball Bearing Factory. Your class will divide into several groups each having very different interests, and will hold a town meeting to discuss and vote on Zanec's proposal.

Objective

Your class will gain experience in recognizing potential hazards to a community's water supply and weighing the risks and benefits of community development, and will practice decision-making skills in a mock town meeting.

General Procedures

1. After reading over the activity's introduction and objectives as a class, begin preparing for the town meeting by randomly dividing your class into five groups.

2. Once the groups are formed, they should take (at home or in class) the time they need to:

a) study the facts of Priceford's water resources.

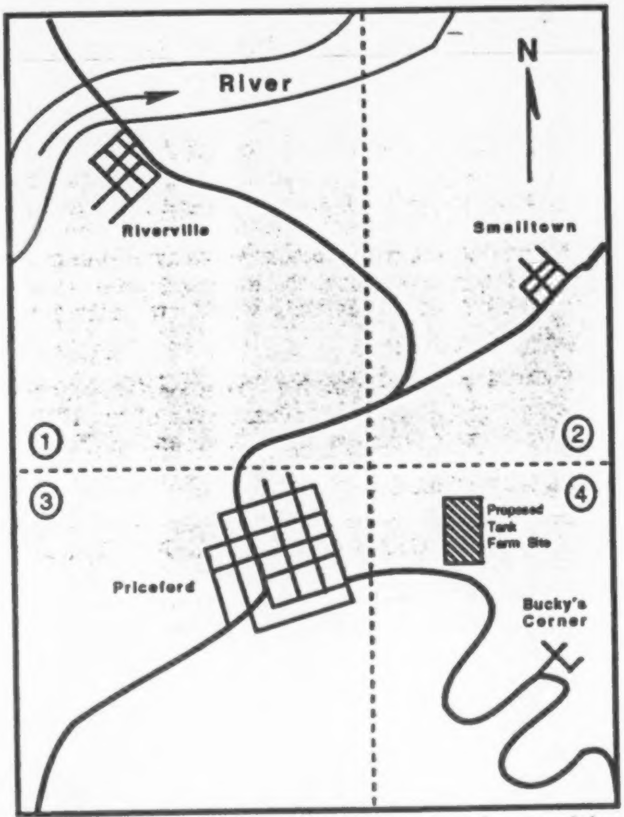
b) elaborate on their own special group's interests.

c) discuss how each item of Zanec's proposal affects their interests.

The background information each group will need for these three tasks is given below. Each group should also select its own spokesperson to represent the group's interests at the meeting.

3. When each group is ready, the Town Council should call the town meeting to order, read the Agenda and introduce the Zanec and Business group to present their proposal. Each other group should then be allowed to comment on the proposal.

4. The Council will summarize the issues it believes to be important, BRIEFLY support or refute each issue and then vote on the proposal.



Priceford's Water Resources

Priceford gets more than half its water from municipal and private wells. The vulnerability of the underlying aquifer in each quadrant of the map below was assessed in the Resource Management Activity (use the vulnerability "scores" calculated for the four quadrants in this activity).

- Quadrant 1 is largely undeveloped in the Priceford area. A small community, Riverville, is about 25 miles down the river. This quadrant is least acceptable to Zanec due to its distance from its property in quadrant 4.

- Quadrant 2 is largely farmland but also contains a small community which relies on well water.
- Quadrant 3 includes Priceford town center and all the residential areas for the town's citizens.
- Quadrant 4 contains a factory just north of Bucky's Corner. Zanec proposes installing the USTs here.

Special Group Interests

1. THE TOWN COUNCIL - You must conduct the meeting, listen to all the arguments, and to decide what is best for all citizens. Based on the facts you gather, the most logical arguments made by any of the groups and your best judgement, you will vote on whether to:

1) allow Zanec to install the tank farm as proposed, OR
2) allow installation only with certain changes in the proposal, OR
3) reject the proposal completely.

2. ZANEC and the local BUSINESS GROUP - You must stress the need to allow the Ball Bearing plant to expand and to attract new businesses for Priceford's economic well-being.

3. LOCAL HOME OWNERS - You are divided. Some desire the new jobs and prosperity made possible by developments like this; others worry about the potential for water, air and noise pollution; still others are concerned about property values; and others are concerned about taxes needed to meet the increased solid waste disposal and sewage demands which are related to development.

4. SAVE THE ENVIRONMENT - Your local chapter of this national group opposes the installation of any USTs until extensive testing has been done and sufficient safeguards are in place. You favor the least vulnerable (but least accessible) site.

5. THE COUNTY HEALTH DEPARTMENT - You are essentially neutral as long as the proposed installation complies with all county health laws and procedures. You must find out whether the proposal meets these standards.

Zanec's Proposal

Zanec is a major development company which has already invested heavily in the Priceford area. The proposed tank farm is only one improvement in its existing developments. Zanec believes its proposal is in the interest of Priceford for the following reasons:

- The tank farm will allow the Ball Bearing plant to expand, bringing about 250 new jobs to an area that has an unemployment rate which is above the state average.
- The company will bring revenues to Priceford, not only through wages, but also through property taxes, income taxes and more consumer spending by its workers and their families.
- The Ball Bearing plant expansion will be attractively designed, well-maintained and an asset to the community.
- The UST Installation will comply with all current regulations and is critical to whether Zanec can continue to build in Priceford
- The new jobs will result in new home building and increased property values.
- Taxes paid by the plant will help finance school and road improvements while helping to keep home owner's taxes low.
- Zanec requests permission to site its tank farm on its property in Quadrant 4 (see map)

Town Meeting Agenda

This notice was published in the Priceford newspaper:

TO ALL CONCERNED PARTIES

An open meeting will be held for community review and input on Zanec Corporation's proposed installation of five 10,000 gallon underground storage tanks on property to the Ball Bearing factory. All interested groups are to have selected spokespersons who will each be given 4 minutes to present their views. The public is invited to comment on the following issues:

1. Should Zanec be allowed to install the USTs at the proposed site?
2. If not, what alternative location is acceptable to all parties
3. What are the risks related to the proposal?
4. How can the risks be minimized to protect ground water?

The remainder of the meeting will consist of a question and answer period after which the Council will vote on the proposal.

Location: Priceford Town Hall
Time: Friday Afternoon

The town meeting Agenda should serve as a guide for the Town Council to conduct the meeting. As stated in the notice the Council should allow each group only 4 minutes to offer their views on each of the questions on the Agenda.

When all groups have been heard, each Town Council member may ask one question of one group. Finally, the Council will vote on the proposal. The Council's vote should be based to a large degree on the most logical and persuasive arguments raised by the groups.

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EPA ENVIRONMENTAL EDUCATION

WATER FILTRATION

BACKGROUND: Water in lakes, rivers, and swamps often contains impurities that make it look and smell bad. The water may also contain bacteria and other microbiological organisms that can cause disease. Consequently, water from surface water sources must be "cleaned" before it can be consumed by people. Water treatment plants typically clean water by taking it through the following processes: (1) **aeration**; (2) **coagulation**; (3) **sedimentation**; (4) **filtration**; and (5) **disinfection**. Demonstration projects for the first four processes are included below.

OBJECTIVE: To demonstrate the procedures that municipal water plants use to purify water for drinking.

MATERIALS NEEDED:

5 liters of "swamp water" (or add 2 ½ cups of dirt or mud to 5 liters of water)
1 two-liter plastic soft drink bottle with its cap (or cork that fits tightly into the neck)
2 two-liter plastic soft drink bottles—1 with the top removed, 1 with the bottom removed
1 one-and-one-half-liter (or larger) beaker (or another soft drink bottle bottom)
20 grams of alum (potassium aluminum sulfate—approximately 2 tablespoons)
(Hint: should be available in pharmacy or spice aisle in grocery store)

Fine sand (about 800 ml in volume)
Course sand (about 800 ml in volume)
Small pebbles (about 400 ml in volume)
(Hint: washed natural color aquarium rocks will work)

1 large (500 ml or larger) beaker or jar
1 coffee filter
1 rubber band
1 tablespoon
1 clock with a second hand (or a stopwatch)

PROCEDURE:

1. Pour about 1.5 liters of the swamp water into a 2-liter bottle. Have students describe the appearance and smell of the water.

2. **Aeration** is the addition of air to water. It allows gases trapped in the water to escape and adds oxygen to the water. Place the cap on the bottle and shake the water vigorously for 30 seconds. Continue the aeration process by pouring the water into either one of the cut-off bottles, and then pour the water back and forth between the cut-off bottles 10 times. Ask students to describe any changes they observe. Pour the aerated water into a bottle with its top cut off.

3. **Coagulation** is the process by which dirt and other suspended solid particles are chemically "stuck together" into floc so that they can be removed from water. With the tablespoon, add 20 grams of alum crystals to the swamp water. Slowly stir the mixture for 5 minutes.

4. **Sedimentation** is the process that occurs when gravity pulls the particles of floc (clumps of alum and sediment) to the bottom of the cylinder. Allow the water to stand undisturbed in the cylinder. Ask

students to observe the water at 5 minute intervals for a total of 20 minutes and write their observations with respect to changes in the water's appearance.

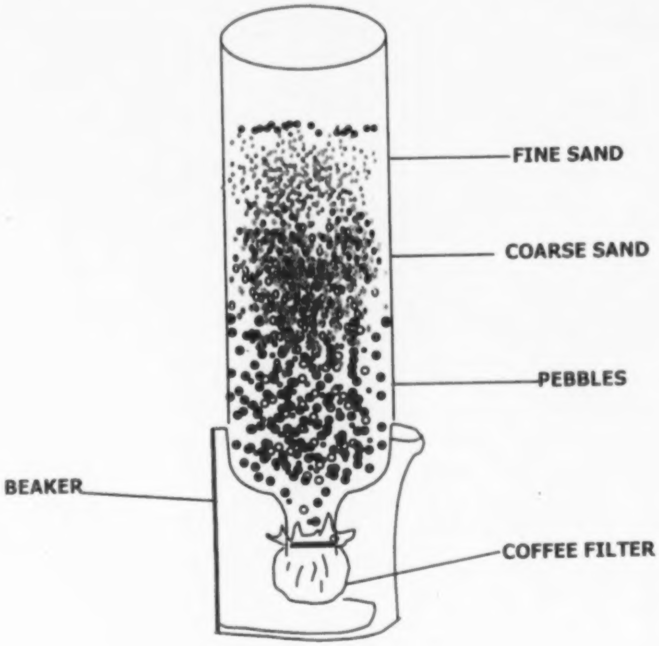
5. Construct a filter from the bottle with its bottom cut off as follows:

   a. Attach the coffee filter to the outside neck of the bottle with a rubber band. Turn the bottle upside down and pour a layer of pebbles into the bottle—the filter will prevent the pebbles from falling out of the neck.

   b. Pour the coarse sand on top of the pebbles.

   c. Pour the fine sand on top of the coarse sand.

   d. Clean the filter by slowly and carefully pouring through 5 liters (or more) of clean tap water. Try not to disturb the top layer of sand as you pour the water.



6. **Filtration** through a sand and pebble filter removes most of the impurities remaining in water after coagulation and sedimentation have taken place. After a large amount of sediment has settled on the bottom of the bottle of swamp water, carefully—without disturbing the sediment—pour the top two-thirds of the swamp water through the filter. Collect the filtered water in the beaker. Pour the remaining (one-third bottle) swamp water back into the collection container. Compare the treated and untreated water. Ask students whether treatment has changed the appearance and smell of the water.

Advise students that the final step at the treatment plant is to add disinfectants to the water to purify it and kill any organisms that may be harmful. Because the disinfectants are caustic and must be handled carefully, it is not presented in this experiment. The water that was just filtered is therefore unfit to drink and can cause adverse effects. It's not safe to drink!

[redacted]

Give drinking water a hand.

CLASSROOM ACTIVITY: WATER CONTAMINATION

The following activity is offered to help students understand how they can give drinking water a hand.

Objective
Students will create a miniature well so they can observe the effects of ground water contamination.

Taxonomy Level
Comprehension

Time Needed
30 minutes

Teacher's Notes
Approximately 53 percent of the population in the United States gets its water from underground aquifers. An aquifer is a geological (created by rocks) formation containing water. Like the holes in a sponge, an aquifer has openings or pores that can store water. Water for drinking is drawn up to the surface by a well or spring. The world's largest aquifer is the Ogallala Aquifer which extends from Nebraska to Texas.

Since water seeps down through soil into the aquifer, the soil filters the water. But, many activities threaten the safety of this source of drinking water. Gasoline and other harmful liquids have been allowed to leak from underground storage tanks into the ground water supply. Pollutants can seep into ground water from poorly constructed landfills or septic systems. Ground water can also be polluted by runoff from fertilized fields or livestock areas. Homeowners unknowingly contribute to ground water contamination by dumping toxic chemicals down the drain or pouring them on the ground.

Materials Needed
Cup for each student
6 inches (150 millimeters) of nylon net per student
Plastic tie for each student
One eyedropper for every three students –
One bottle of vegetable-oil food dye (red, green, or blue) for every three students
Enough water to fill each student's cup
Enough potting soil to fill each student's cup
Pencil for each student

Activity Directions
Students should wrap the nylon around their pencil and secure it with the plastic tie. Put the nylon-wrapped pencil in the middle of the cup, so it can act as a "well." Carefully place the soil in the cup around the nylon-wrapped pencil. Finally, untie the plastic tie and slip the pencil out of the soil (allowing the nylon to remain in the hole) and pour water into the cup.

After a few minutes, the water should appear in the opening of the well. Students should remove water with the eyedropper and see that it is clear in color. After returning the water to the well, students can add a drop of food dye to the surrounding soil to represent contamination. After a few minutes, remove water again with the eyedropper. This time the water should have color in it from the dye.

Questions to Expand Students' Thinking
What would happen to the lakes and rivers that are fed by water from this aquifer?

What types of things in your household, if poured on the ground, might contaminate drinking water?

Should you throw toxic household items in the trash?

Source: Intermediate Te 3DX, American Water Works Association, 6666 West Quincy Avenue, Denver, CO 80235.

[redacted]

[redacted]

THUMB BLUE BLUE THUMB

Give drinking water a hand.

CLASSROOM ACTIVITY: PUBLIC INVOLVEMENT

The following activity is offered to help students understand how they can give drinking water a hand.

Objective
Students get a Blue Thumb by surveying public understanding of drinking water.

Taxonomy Level
Synthesis

Time Needed
30 minutes for survey preparation; 2 evenings for data collection; 30 minutes for classroom discussion

Teacher's Notes
Using the scientific method as a format, students will develop a 10-question survey. The survey will help the students collect data from the public about what people know about their drinking water. Once the students process the results, they may design a poster or write a essay to inform people about their drinking water.

Materials Needed
General information about the local water agency

Pencil and paper

Information about the water source, source protection, and conservation from the local water district.

Activity Directions
Have the students generate 10 questions, either as a group project or individually, that will assess the public's understanding of drinking water issues. Try to have as many "yes" and "no" answers as possible. Suggested questions might be as follows:

- Do you know the source of your drinking water?
- Do you know how water is treated?
- Do you know who runs your water department?
- Do you know where the water goes after it has been used in the home?
- Do you try to conserve water?
- Does your hose have an automatic shut-off valve?
- Is water an important issue in our community?

Once the questions have been chosen, have the students decide on their hypothesis, such as "our survey shows that many people in the community think water is an important issue," or "most people try to conserve water." The hypothesis should directly relate to what the students think that the results of their survey will be. You can let the students' hypothesis be very general (if they are not used to working with a scientific method) or very specific. Next, have the students decide on the target group – those people that you will ask the questions. Some possible target groups are parents, family members, fellow students, or neighbors.

Now comes the fun part–gathering the data. Have the students talk to their audience face-to-face, in order for them to get a feel for what the public is thinking about water. Decide together on how many people each student will need to talk to in order to get a substantial finding. The students should record the answers to their questions and bring the answers back to the class.

At the conclusion of the survey, the students will need to compare and contrast the responses.

Questions to Expand Students' Thinking
Do the answers the students got back from their survey agree with their hypothesis?

What was the most surprising result that the students found from their survey?

What can the students do to make sure everyone gets a Blue Thumb?

Source: Intermediate Teachers' Guide to Story of Drinking Water, Second Edition, Dale, 1991, Catalog 70003DX, American Water Works Association, 6666 West Quincy Avenue, Denver, CO 80235.

[redacted]

Give drinking water a hand.

Instructions for distributing the Blue Thumb Game

1. Make copies of the Blue Thumb Game instructions on colored paper.

2. Use the blanks to type in questions and answers that are specific to your area, like:

- Q: What is the largest river in (insert name of state)?
- Q: Annual precipitation in (insert name of state)?
- Q: What three types of pollution threaten (insert name of source)?

3. Make copies of the Blue Thumb Cards on heavy colored paper (card stock). One side will have the Blue Thumb graphics and the other side will be the questions and answers. You will have double-sided sheets when you are done.

4. Attach the instruction sheet to the three double-sided Blue Thumb Card sheets. The Blue Thumb game can be included with other materials sent to teachers, youth groups, etc.

BLUE THUMB

Give drinking water a hand.

Instructions to play the Blue Thumb Game

Objective: Students will become more familiar with water-related topics including:

(1) sources of water, (2) the hydrologic cycle, and (3) water treatment.

Materials: Blue Thumb cards, a timer or clock, paper and pencils.

Procedure: This game is similar to the game show Jeopardy, except there is only one topic — water. In the first round correct responses are worth five points, and in the second round correct responses are worth 10 points. In the final round, each team decides how much of their total score they want to wager on the last question. The team with the most points after the final round is the winner. To play the game:

1. Decide on the length of the first and second rounds—either the number of cards that will be read or a time limit for each round.

2. Divide the class into teams and select someone to keep score for each of the teams.

3. Explain how the game will work. Then begin by reading the answer on one of the Blue Thumb cards. For example, "The scientific term for the study of water."

4. The first person who raises his or her hand, when acknowledged, gets to try to give the correct response in the form of a question. For example, "What is hydrology?"

5. If no one raises a hand within ten seconds, continue with the next card.

6. If the person answers correctly, his or her team is awarded the point value of the question. If the person answers incorrectly, the team has to subtract the point value of the question from their score. Note: All responses must be in the form of a question to be correct.

7. When a person responds incorrectly, members from the other teams may then raise their hands and when acknowledged, try to give the correct answer.

8. After completing two rounds of play, it is time for the final round. Have each team write down how much of their score they want to wager in the final Blue Thumb round.

9. Read the final Blue Thumb answer, and give the teams one minute to write down their responses (in the form of a question). You may want to remind them not to talk during the final round, otherwise, members of another team might overhear their response.

Source: North Dakota State University
Extension Service

A. The percentage of the earth's water that is fresh water?

Q. What is 3%?

A. The source of energy for the hydrologic or water cycle.

Q. What is the sun?

A. Two possible sources of groundwater contamination.

Q. What are landfills and septic tanks? (Other acceptable answers include feed lots, human wastes, animal wastes, fertilizers, and abandoned wells.

A. The five Great Lakes.

Q. What are the Huron, Ontario, Michigan, Erie, and Superior?

A. The process by which a vapor becomes a liquid or a solid.

Q. What is condensation?

A. The wearing down or washing away of soil and land by the action of water, wind, or ice.

Q. What is erosion?

A. The capacity of porous materials, such as sand and gravel, to transmit water.

Q. What is permeability?

A. A term used to describe the area drained by a river and its tributaries.

Q. What is a river basin? (Watershed would also be an acceptable answer.)

A. Tanks used to hold waste from homes when a sewer line is not available.

Q. What are septic tanks?

A. The chemical symbol for water.

Q. What is H_2O?

A. The name for a smaller stream that flows into a larger stream.

Q. What is a tributary?

A. The three largest oceans.

Q. What are the Atlantic, Pacific, and Indian?

A. The constant circulation of water from the atmosphere to the land and the oceans, and back again.

Q. What is the water (hydrologic) cycle?

A. The act of adding water to crops.

Q. What is irrigation?

A. The movement of water down through the earth's surface.

Q. What is infiltration? (Percolation would also be an acceptable answer.)

A. Water that carries waste from homes, businesses and industries; a mixture of water and dissolved or suspended solids.

Q. What is waste water? (Sewage would also be an acceptable answer.)

A. An odorless, tasteless, colorless liquid formed by a combination of hydrogen and oxygen molecules that makes up a major portion of all living things.

Q. What is water?

A. A pit, hole, or shaft sunk into the earth to tap an underground source of water.

Q. What is a well?

THUMB BLUE BLUE THUMB
Give drinking water a hand.
THUMB BLUE BLUE THUMB
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Give drinking water a hand.

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89

A. A change in the quality of water that makes it unsuitable for certain uses.

Q. What is pollution? (Contamination would also be an acceptable answer.)

A. Water-saturated lands where aquatic plants and animals live.

Q. What are wetlands?

A. A place where water is treated to make it safe to drink.

Q. What is a water treatment plant?

A. This element is added to water to prevent tooth decay.

Q. What is fluoride?

A. Lack of precipitation for a long period of time.

Q. What is a drought?

A. On average, almost 40% of the water used in a home is used to do this.

Q. What is flush the toilet?

A. The percentage of the human body composed of water.

Q. What is 65%?

A. The percentage of the earth covered with water.

Q. What is 80%?

A. The average number of gallons of water treated in the United States for each person every day.

Q. What is about 180 gallons?

A. The temperature at which water changes from a solid into a liquid or vice versa.

Q. What is 32 degrees Fahrenheit or 0 degrees Celsius?

A. The temperature at which water changes from a liquid to a gas or vice versa.

Q. What is 212 degrees Fahrenheit or 100 degrees Celsius?

A.

Q.

A.

Q.

A.

Q.

A.

Q.

A.

Q.

A.

Q.

A.

Q.

Water Riddle Answers

1. An icicle
2. Ice
3. A riverbank
4. The sea
5. Water, from a tap or a river

Early Egyptians considered the Nile River the source of life itself. For this reason, Egypt is often called, "Gift of the Nile."

Blue Thumb Word Search Answers

												Z	
		R		C		E	E	Z	T	G	N	A	Y
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S		R		T		S	G		R		K	Z	
I		A		O	D	A	R	O	L	O	C	I	
S		N		P	N				N		J		
S		D		G	A			G			S		
I		E	E		M	R			V		E		S
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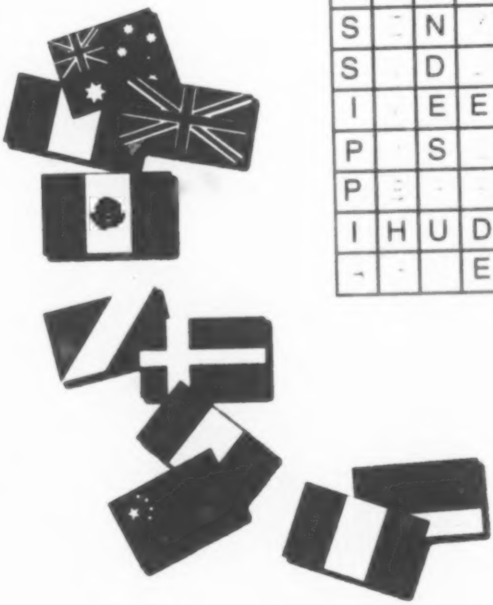


More Fun with Water

Water Riddles

Share these silly water riddles with friends and family.

1. What lives in winter, dies in summer, and grows with its root upward?
2. What three letters mean "stiff water"?
3. What kind of bank needs no money?
4. What runs and has no feet, roars but has no mouth?
5. What runs but never gets tired?

Blue Thumb Word Search

In this word search, look for the names of great rivers. When finished, talk about their geographic location and importance in the lives of people near and far, past and present.

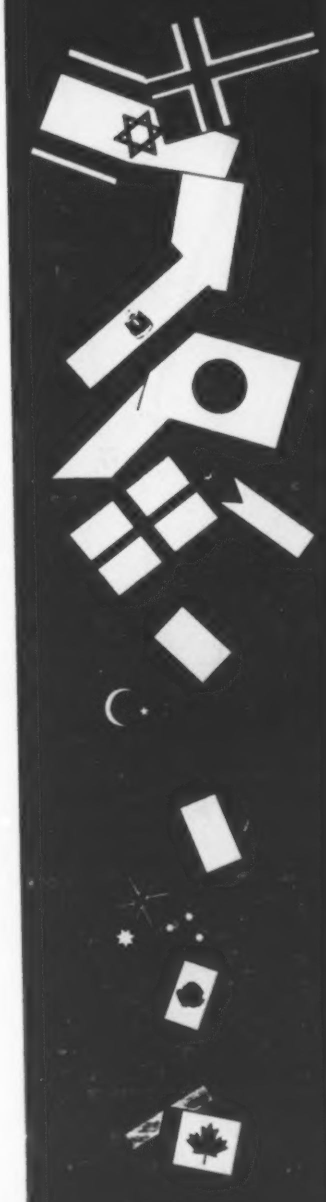
D	J	R	T	B	N	P	Q	H	A	B	I	Z	N
C	Y	R	J	C	X	E	E	Z	T	G	N	A	Y
M	Q	I	P	A	G	N	F	P	Y	T	M	M	O
I	O	O	X	M	N	I	A	G	R	A	T	B	M
S	O	G	N	O	C	E	V	D	N	I	L	E	I
S	X	R	B	T	K	S	G	F	R	D	K	Z	K
I	B	A	V	O	D	A	R	O	L	O	C	I	T
S	Z	N	Y	P	N	O	J	X	N	P	J	P	R
S	J	D	L	G	A	W	N	G	B	Q	S	O	E
I	M	E	E	G	M	R	J	H	V	R	E	E	S
P	Y	S	O	Z	A	H	W	E	O	N	M	T	U
P	B	F	R	E	Z	I	H	L	L	I	A	S	D
I	H	U	D	S	O	N	T	P	G	T	H	L	N
A	S	Q	E	C	N	E	R	W	A	L	T	S	I

Amazon
Colorado
Congo
Ganges
Hudson
Indus
Jordan
Mekong
Mississippi
Niagra
Nile
Potomac
Rhine
Rio Grande
St. Lawrence
Seine
Thames
Volga
Yangtze
Zambezi

Water Proverbs

A proverb is a short phrase or saying that expresses a simple truth or idea. Many proverbs are rooted in a country's ancient cultural heritage or religion. Read each proverb and discuss its meaning.

- You can't learn to swim in a field. *(Spanish)*
- No snowflake ever falls in the wrong place. *(Zen)*
- One step too few is enough to miss the ferry. *(Chinese)*
- Help your brother's boat across and lo! your own has reached the shore. *(Hindu)*
- A small hole can sink a big ship. *(Russian)*
- To rule the mountains is to rule the river. *(Chinese)*



BEST COPY AVAILABLE

Water Questions & Answers

Q. Is it okay to substitute other drinks for the recommended six to eight glasses of water needed each day to maintain good health?

A. Juice, milk, and soft drinks are almost all water, so they do count toward the required daily fluid intake. Nutritionists often recommend tap water because some beverages contain chemicals like caffeine and alcohol that do not help the body maintain fluid balance as well as other drinks.

Q. Why does dishwater or the dishwasher leave spots on glasses?

A. The spots that may appear on glassware after washing and air-drying are caused by nontoxic minerals that remain on the glass when the water evaporates. Spots on glass shower doors appear for the same reason. Commercial products are available that allow the water to drain from glassware more completely.

Q. What is a watershed?

A. A watershed is the region of land where all water drains—or "sheds"—to the same river, reservoir, or other body of water.

Q. In towns and cities, what is the major cause of pollution of drinking water sources?

A. The major source of pollution in towns and cities is rainwater that flows into street catch basins (called urban runoff or stormwater runoff). While the rainwater alone is not necessarily harmful, it frequently carries untreated waste products from our streets and yards directly to rivers, lakes, and streams — our drinking water sources.

Q. Why is ocean water salty?

A. Rainwater doesn't contain any salt, but when it falls on the ground, salt from the soil dissolves in the water as it flows back to the ocean. When this water evaporates from the ocean, the salt stays behind. This process has been going on for more than a billion years. Over that very long period of time the ocean got more salt in it with each cycle.

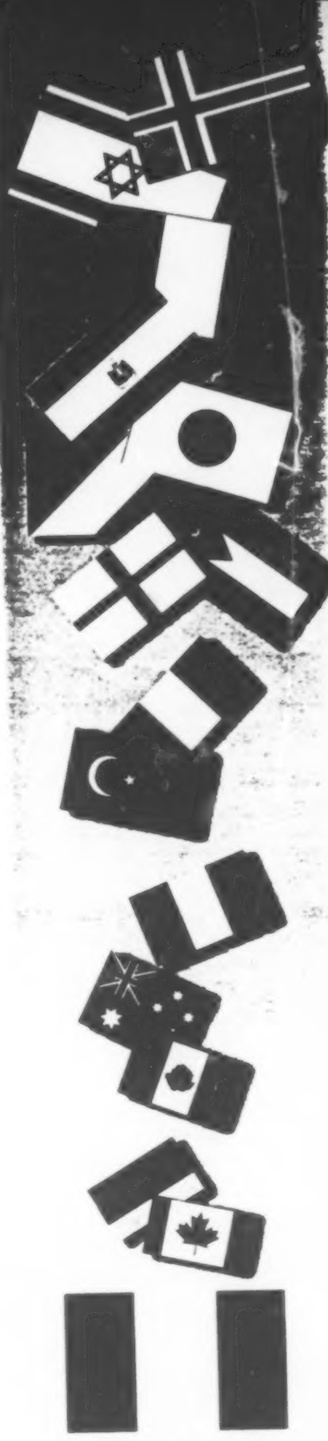
Q. Why does drinking water often look cloudy when first taken from a faucet and then clear up?

A. The cloudy water is caused by tiny air bubbles in the water similar to the gas bubbles in carbonated soft drinks. After a while, the bubbles rise to the top and are gone. This type of cloudiness occurs more often in the winter, when the drinking water is cold.

Q. Why is some drinking water stored in large tanks high above the ground?

A. Two reasons. First, this type of water storage ensures that water pressure and water volume are sufficient enough to fight fires, even if the electricity that normally pumps water is turned off. The second reason is to provide an extra source of drinking water during the day when water use is high. The water storage tanks are refilled at night when drinking water use is low.

These questions and answer are from Plain Talk About Drinking Water: Questions and Answers About the Water You Drink by Dr. James M. Symons, published by American Water Works Association, copyright © 1997.



Q. He is France's most famous oceanographer, author, and environmentalist?

A. Jacques Cousteau

Focus on Water

To keep water clean or to make sure there is plenty to drink, we need to understand where water comes from, how it flows, and how it's used at home, in schools, on farms, and in the community. In other words, it's time to get to know your watershed!

What to Do

A. Go outside and look at your surroundings. You can start anywhere—at your home, school, farm, or even downtown. Go to the highest point you can see within easy walking distance. If possible, go to the highest point in your community.

B. Look over the land and the way the ground slopes down from this high point. If it rained, where would water flow? You're looking at a *watershed* or several watersheds. That is the area of land where all water drains or "sheds" to the same body of water. Walk around this area. Look for the following things in your watershed.

In my watershed, water flows to:

☐ low points
☐ ditches
☐ ____________
☐ gutters
☐ lakes/streams/rivers
☐ ____________
☐ storm drains
☐ culverts
☐ ____________

On its way, it passes:

☐ bare soil
☐ streets
☐ industry
☐ litter
☐ ____________
☐ grass/trees/shrubs
☐ shopping centers
☐ school
☐ farms
☐ ____________
☐ wells
☐ parking lots
☐ houses
☐ animals
☐ ____________

C. Does anything you see look like a possible water concern?

▶ For example, is there bare soil? Is there erosion with soil washing into waterways?

Can you find places where water has been carefully protected?

▶ For example, is grass planted on paths to keep soil from washing away?

Write down things you like and things that don't look right. If you aren't sure which things are helpful or are problems, just record what you do see for now. Later, you can share what you found with a natural resources expert in your community.

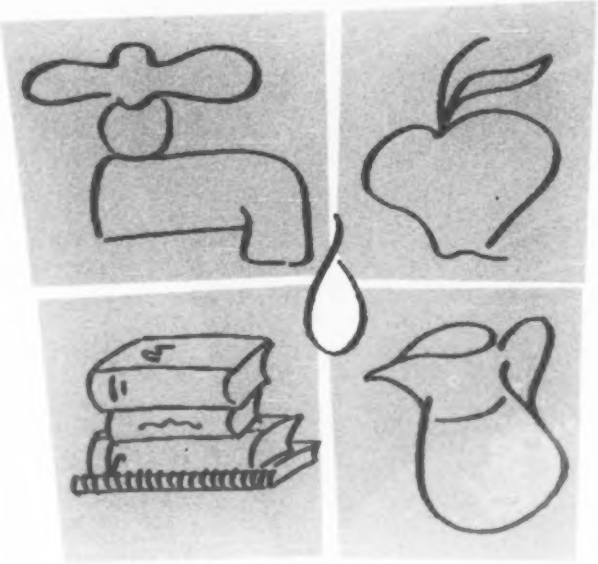
D. Brainstorm a list of the ways you can affect water. Be sure to think of activities inside and outside. See how many ideas you can come up with. Two examples are: watering the grass and having a school car wash.

▶ What activities use water?
▶ What activities create wastewater?
▶ What do you already do to conserve or protect water?

One fifth of
the world's
fresh water
is in Canada.

Adapted from Give Water A Hand, *© 1996 University of Wisconsin Board of Regents. UWEX-Environmental Resources Center*

General Information



United States
Environmental Protection
Agency

Office of Water
Washington, D.C. 20460

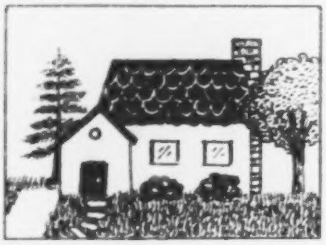
EPA 570/9-91-100

EPA

Fact Sheet: 21 Water Conservation Measures for Everybody

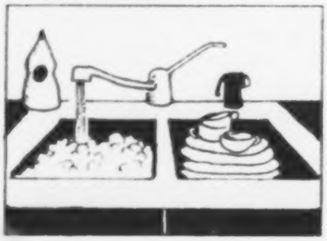
The earth is covered with water, yet only one percent is available for drinking. Unfortunately, many of us take this small percentage for granted. The average adult needs only 2-1/2 quarts of water per day to maintain health, but in the United States, we each use 125 to 150 gallons per day for cooking, washing, flushing, and watering. That's over 40 percent more water than we need to accomplish these tasks. Our wasteful habits not only deplete clean water reserves faster than we can replenish them, but they pollute many waterways, rendering them unfit for human consumption. They also stress aging drinking water and sewage treatment facilities beyond their capacities. In each of the past few years, wastewater treatment systems dumped an estimated 2.3 trillion gallons of inadequately treated sewage into U.S. coastal waters, destroying beaches, fisheries, and other marine life.*

We waste water both by practicing bad habits, like leaving the water running when we brush our teeth, and by using antiquated equipment not built with water conservation in mind. Bad habits can be difficult to change, but new ones can save thousands of gallons of water per year per person. Installing new water-saving equipment and small devices also can save significant amounts of water per household without requiring us to change our daily routines. Many devices are inexpensive, available in local hardware stores, and easy to install. They can save energy (and energy bills) too! By following a few simple steps, a typical family of four can save an astounding 50,000 to 100,000 gallons of water per year. What are we waiting for?



For Every Room in the House

- Repair leaky faucets, indoors and out. One leaky faucet can use up to 4,000 gallons of water per month.
- Install faucet aerators. These inexpensive devices can reduce water use up to 60 percent, while maintaining a strong flow.



In the Kitchen

- When cooking, save 10 to 15 gallons of water per meal by peeling and cleaning vegetables in a large bowl of water instead of under the running tap.
- When handwashing dishes, save 15 gallons of water by soaking dirty dishes in the basin, then rinsing them off.
- Run full-load dishwashers to save 15 gallons per load and hot water costs, too.
- When buying a new dishwasher, select one with a "light-wash" option. Newer models use 20 percent less water than older ones.

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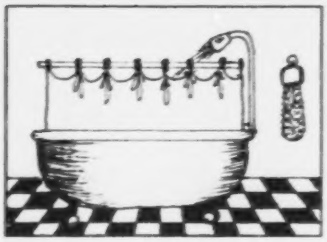
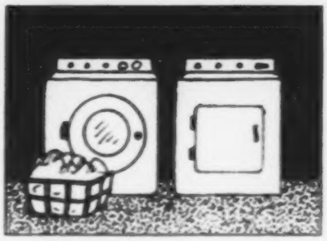
*Congress of the United States, Office of Technology Assessment, 1987. Waste in the Marine Environment. Washington, D.C.

Printed on Recycled Paper



In the Bathroom

- Take short showers instead of baths. Showers use an average of 5 to 7 gallons per minute, three times less than the water used to take a bath.
- Install a low-flow showerhead. This will cut water use in the shower to just 3 gallons per minute and still provide an invigorating flow.
- Turn off the water to brush teeth, shave, and soap up in the shower. Filling the sink to shave uses only 1 gallon, while letting the water run can use 10 gallons per shave or more. Turning off the water when you brush your teeth can save 4 gallons of water each time.
- Repair leaky toilets to save more than 50 gallons of water per day. Add 12 drops of food coloring into the tank. If color appears in the bowl one hour later, the unit is leaking.
- Install a toilet displacement device to save thousands of gallons of water per year or 5 to 7 gallons per flush. Place one to three weighted plastic jugs into the tank, making sure the jugs don't interfere with the flushing mechanism or a suitable flow. Or, instead of jugs, use toilet dams that hold back a reservoir of water during each flush, saving 1 to 2 gallons. Don't use bricks because they can chip and foul the flushing mechanism.
- When buying a new toilet, select a low-flush model that uses less than 1-1/2 gallons of water to flush, saving over 7,000 gallons per year per person.



On Wash Day

- When purchasing a new washing machine, buy a water-saving model that can be adjusted to load-size and has a "suds-saving" option. New models use 40 percent less water than older models.
- For old and new machines, run full loads only.

Taking Water Conservation Outdoors

- Mow your lawn with water retention in mind. Set mower blades on a high setting (2- to 3-inch grass length as opposed to golf-course short) to provide natural ground shade and promote water retention by the soil.
- Water lawn and garden in the morning when evaporation is lowest.
- Water no more than 1 inch per week, applied slowly to prevent runoff. Place several empty cans around the yard when watering to determine how long it will take to water 1 inch.
- Collect rainwater for watering plants using a barrel covered with a screen.
- Plant indigenous species suited to your area and save as much as 54 percent of the water used to care for outdoor plants. Ask your local nursery for plant and grass species that require less water.
- When washing your car, turn off the hose between rinses to save up to 150 gallons per washing.
- Sweep down decks and driveways instead of hosing them down.

[illegible] BLOOPERS: Embarrassing moments in the life of a water drinker.

BLUE THUMB
Give drinking water a hand.

1. Waiting a week to fix a leak.

Assume little leaks only waste a little water? You can lose up to 200 gallons of water a day from a leaking toilet. And a faucet can drip 604,800 drops while you're waiting.

2. Slipping used motor oil into a storm sewer or burying it in the trash.

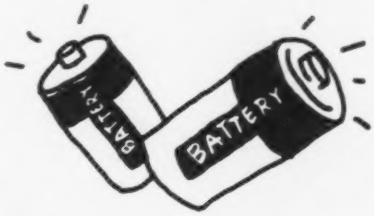
Hey slick, oil can leach into lakes, rivers, and wells. Just one pint can expand over an acre of water. Take your used oil to a recycling center.

3. Watering your lawn at high noon.

Caught with your sprinkler on? The hot sun will evaporate the water your lawn needs. Better water early in the day.

4. Taking a shortcut and using the hot water tap when cooking.

That's taboo, and it can shortcut your health. Lead can dissolve into hot water from lead pipes and solder. Cold water is better. Heat it on the stove when cooking or making baby formula.



5. Tossing toxics in the trash.

How tacky! Consider batteries, a common throw-away. They contain lead and mercury. Some ordinary household cleaners have other poisons that contaminate water. Here's a tip, drop them off at a special collection site.

6. Using your garbage disposal all the time.

Want to show good taste after a meal? With your disposal using one gallon of water a minute, compost those food scraps. Another benefit, you'll be creating a great soil conditioner.

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BLUE THUMB

Give drinking water a hand.

7. Failing to check for the recycled mark on paper before buying it.

Still think recycled paper only helps trees? Recycled paper reduces water pollution from paper production by 35 percent. It saves water too — 7,000 gallons for every ton of paper.

8. Using electricity as if it didn't affect water.

It's time to shed some light on this. It takes more than 130 billion gallons of water a day to generate electricity in the U.S. Conserving energy is conserving water.

9. Thinking you can't make a difference.

It's never a blooper to take a stand for clean water, through your actions and through your words. So put your Blue Thumb knowledge to work and give drinking water a hand every day.

To find out more, order the "Blue Thumb Basics" brochure listing more than 50 additional ways to conserve and protect your drinking water. Send a self-addressed, stamped envelope to "Blue Thumb Basics," Public Information Department, American Water Works Association, 6666 W. Quincy Ave., Denver, CO 80235.

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THUMB BLUE BLUE THUMB

Give drinking water a hand.

1. Know Your Drinking Water

Understand where your water supply comes from. Write your water supplier and request the list and schedule of water quality tests required by the Environmental Protection Agency. Study local well codes and ask your County Health Department for assistance before you drill a new well. Always hire a licensed driller for water well drilling and pump installation.

2. Test Your Well

There are more than 13 million wells supplying drinking water to people in the United States — most wells produce safe drinking water, but contamination can occur. If you have a well, have it regularly tested for contamination. The fact that a neighbor's well tests safe does not mean that your well is safe. Overloaded septic systems may be a source of well contamination. Ask your County Health Department for assistance.

3. Plug Abandoned Wells

Identify the abandoned water wells in your area or on your property and have them plugged by a licensed well driller. An open, abandoned well can draw contaminants directly from the surface into the aquifer below. In the past, some abandoned wells have been used for waste disposal.

4. Septic System Maintenance

If you have a septic system, pump it out every one to three years. Do not flush grease, caustics, and non-biodegradable materials into the system. Before installing a new septic system, read local code requirements. Have your system installed by a licensed individual. Do not use septic tank cleaners. They are not needed and can prove harmful.

5. Yank that Tank

Those old rusty underground storage tanks for oil and gasoline have become a menace. Federal law requires that abandoned underground storage tanks be removed from the ground and that leaking tanks must be replaced. If you have an underground tank on your property, have it checked for leaks.

6. Healthy Farming and Gardening

Pesticides and fertilizers leach down through the soil and into the groundwater below. If you farm or garden, practice the best livestock manure management practices available and test the soil to avoid over-application of fertilizers. Follow label recommendations for proper pesticide application. Do not apply chemicals if heavy rain is forecast. Learn about IPM (Integrated Pest Management). Contact your County Extension Office for further information.

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7. Reduce, Reuse, Recycle

These are the three R's for those who are environmentally conscious. By molding our lifestyles after these three words, we can help prevent contamination of our groundwater resources. Remember, what goes into our garbage goes into our ground, and what goes into our ground goes into our groundwater.

8. Buy Recycled Products

Unless we demand recycled products there will not be a market for them. To strengthen the market, request recycled products at the local grocery store. Products made from recycled materials use only about half as much energy to produce. Paper made from recycled fibers reduces air pollution, saves trees, and creates five times as many jobs as paper made from virgin wood. Ask your local store to carry recycled products.

9. Become a Green Consumer

You can buy products which do not tax the environment or push toxins into your groundwater. A green product is one that has environmentally sound contents or is wrapped in environmentally sound packaging. Buy in bulk. Buy the economy size. Take your grocery bags back for a second trip. By becoming a green consumer you will save money by not purchasing packaging you will throw away as soon as you get home. SAY NO! to products that are over-packaged.

We all have it within our power to protect our drinking water.

Source: Michigan Tip of the Mit Watershed Council, adapted from the GEM Regional Groundwater Center "Ten Steps to Protect Your Drinking Water" poster

WHAT YOU SHOULD KNOW ABOUT YOUR COMMUNITY DRINKING WATER...

THUMB BLUE THUMB BLUE

Give drinking water a hand.

Instructions:
(fill in answers, "white-out" directions, duplicate or print, and distribute)

Drinking Water Source(s):

Possible types of pollution:

Programs in place to protect the source:

Water provider:

Number of households receiving water:

Types of treatments used:

Number of tests done to test water quality:

Does the finished water meet or exceed USEPA standards?:

What are the key issues in terms of assuring the high quality of the community's water supply?:

How can the community join with the professionals to work on those issues?

Please contact the following organizations for more information.

conserve

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Be Hydro-Logical

FACT: More water is used in the bathroom than any other place in the home.
ACTION: Turn off the water when you brush your teeth and shave. Install low-flow toilets, shower heads and faucet aerators and you'll save thousands of gallons/liters of water a year. It's a savings that should reduce your water bill.

FACT: Today there are many more people using the same amount of water we had 100 years ago.
ACTION: Don't waste water. Use it wisely and cut back wherever you can.

FACT: A dripping faucet can waste up to 2,000 gallons/7,600 liters of water a year. A leaky toilet can waste as much as 200 gallons/260 liters of water a day.
ACTION: Check your plumbing and repair any leaks as soon as possible.

FACT: Lead in household plumbing can get into your water.
ACTION: Find out if your pipes are lead or if lead solder was used to connect the pipes. If you have lead in your plumbing system, when you turn on the tap for drinking or cooking, let the water run until it's cold. Never use water from the hot tap for cooking or drinking.

FACT: What's dumped on the ground, poured down the drain, or tossed in the trash can pollute the sources of our drinking water.
ACTION: Take used motor oil and other automotive fluids to an automotive service center that recycles them. Patronize automotive centers and stores that accept batteries for recycling. Take leftover paint, solvents, and toxic household products to special collection centers.

FACT: On average, 50% - 70% of household water is used outdoors for watering lawns and gardens.
ACTION: Make the most of the water you use outdoors by never watering at the hottest times of the day or when it's windy. Turn off your sprinklers when it's raining. Plant low-water use grasses and shrubs to reduce your lawn watering by 20% - 50%.

FACT: Lawn and garden pesticides and fertilizers can pollute the water.
ACTION: Reduce your use of pesticides and fertilizers and look for safer alternatives to control weeds and bugs. For example, geraniums repel Japanese beetles; garlic and mint repel aphids; and marigolds repel white flies.

FACT: Although most people get their water from regulated community water supplies, others rely on their own private wells and are responsible for their own water quality.
ACTION: If you own a well, contact your local health department or Cooperative Extension Service representative to find out how to test the quality of your well water.

FACT: Your city government and state officials regularly make decisions that affect the quality of your drinking water resources.
ACTION: As the population grows and housing and industrial interest expand, attend local planning and zoning meetings and ask what's being done to protect water resources from contamination. Let elected officials know that you expect them to use their hydro-logic to protect the water.

FACT: Public water utilities regularly test the quality of the drinking water they provide to customers.
ACTION: Call your water utility and ask for a copy of their latest water quality report.

Water Myths & Realities

Myth: We have less water today than we did 100 years ago.
Reality: There is the same amount of water on Earth today as there was when the Earth was formed three billion years ago. The difference is that today many more demands are placed on water. Because our demands on water continue to grow but our supplies don't, everyone should lend a hand to conserve, protect, and get involved with decisions that affect our water resources.

Myth: We don't have to think about drinking water.
Reality: We can no longer take our drinking water for granted. Public participation is vital to protecting our water resources, building adequate treatment plants, improving water delivery, analyzing costs versus risks, and enacting appropriate legislation.

Myth: Once you use water, it's gone.
Reality: After water is used, it's recycled ... innumerable times. Some water is recycled for use within a week, other water may not be used again for years. Water is resilient and responds well to treatment. However, using water and abusing water by contaminating lakes, streams, and wells with toxic chemicals are two different things. To keep our drinking water safe, we need not only appropriate treatment, but also appropriate source protection.

Myth: If lead is in your water, it's the treatment plant's fault.
Reality: The most common source of lead in drinking water is plumbing in your home. Your plumbing may have lead pipes or lead solder in the connections. Lead is a contaminant that is particularly harmful to pregnant women and young children. If you are concerned about lead in your water, contact your local health authorities or water utility to find out how you can have your water tested by a certified laboratory. If tests reveal that the lead content of your water is above 15 parts per billion, you should reduce your exposure to it. Hints: 1. Since warm water absorbs more lead than cold, always use cold water when you cook. 2. Because water standing in pipes tends to absorb lead, clear the pipes before drinking by letting your tap run until the water is cold.

Myth: There are more pollutants in drinking water today than there were 25 years ago.
Reality: Not necessarily. Twenty-five years ago, we did not have the technology to know what was in our drinking water. Today, we have sophisticated testing instruments that enable us to know more about our water than ever before. The drinking water community is continually improving treatment processes as it learns more each year.

Myth: Using a home water treatment device will make tap water safer or healthier to drink.
Reality: Some people use home water filters to improve the taste, smell, or appearance of their tap water, but it does not necessarily make the water safer or healthier to drink. Additionally, all home treatment devices require regular maintenance. If the maintenance is not performed properly, water quality problems may result.

Myth: Bottled water is safer than tap water.
Reality: Not necessarily. Unlike tap water, the quality of finished bottled water is not government-monitored. Studies have shown that microbes may grow in the bottles while on grocers' shelves. You don't need to buy bottled water for safety reasons if your tap water meets all federal, state, or provincial drinking water standards. If you want water with a different taste, you can buy bottled water, but it costs up to 1,000 times more than tap water. Of course, in emergencies, bottled water can be a vital source of drinking water for people without water.

Myth: "New" water is better than treated water.
Reality: There is very little water on Earth that is new. Most of our water has been touched by some type of human or animal activity. Even in remote wilderness areas, studies have found bacteria contaminating water. Therefore, it's always best to drink water that you know has been treated. Before drinking water from a stream, boil it for one minute at sea level or three minutes at higher elevations. This will completely kill all bacteria, viruses, and germs.

Water Q & A

Q. Can I tell if my drinking water is okay by just looking at it, tasting it, or smelling it?
A. No. None of the chemicals or microbes that could make you sick can be seen, tasted, or smelled.

Q. When I'm working in the yard, I'm tempted to take a drink from my garden hose. Is this safe?
A. No. The water is safe, but a standard vinyl garden hose has substances in it to keep it flexible. These chemicals, which may get into the water as it goes through the hose, are not good for you. In addition, the outside thread openings at the end could be covered with germs.

Q. If I travel overseas, in which countries is the water safe to drink?
A. Besides the United States and Canada, the water is generally safe to drink in western Europe, Australia, New Zealand, and Japan. In other countries, you should insist on carbonated bottled water for drinking and brushing your teeth.

Q. Is the fluoride and chlorine in my drinking water safe?
A. Yes. When added or naturally present in the correct amounts, fluoride in drinking water has greatly improved the dental health of American and Canadian consumers. Many tests have shown that the amount of chlorine found in treated water is safe to drink, although some people object to the taste. NOTE: even in the correct amounts, fluoride or the disinfectant chloramine in drinking water makes the water unsuitable for use in kidney dialysis machines or aquariums.

Q. Water often looks cloudy when first taken from a faucet and then it clears up. Why is that?
A. The cloudy water is caused by tiny air bubbles in the water similar to the gas bubbles in beer and carbonated soft drinks. After a while, the bubbles rise to the top and are gone.

Q. What is "hard" water?
A. The answer may surprise you. Hardness in drinking water is caused by two nontoxic chemicals-usually called minerals — calcium and magnesium. If either of these minerals is present in your water in substantial amounts, the water is said to be "hard," because making a lather or suds for washing is "hard" (difficult) to do. Thus cleaning with hard water is difficult. Water containing little calcium or magnesium is called "soft" water. (Maybe it should be called easy, the opposite of difficult.) Water that does not contain enough calcium or magnesium may be "too soft."

Q. What is the cost of the water I use in my home?
A. Prices vary greatly around the United States and Canada, but the typical cost is about $2 for 1,000 gallons/3785 litres. At that price you get approximately 5 gallons/20 litres of tap water for a penny.

Q. Many areas near the ocean do not have large supplies of fresh water. Why can't ocean water be treated to make drinking water
A. Ocean water can be treated, but the process is expensive. The cost of converting salt water to drinking water has been estimated at $5 to $7 for each 1,000 gallons/3785 litres instead of the $.30 to $.50 for treating 1,000 gallons/3785 litres of fresh water.

Q. Why is ocean water salty?
A. Rainwater doesn't contain any salt, but when it falls on the ground, salt from the soil dissolves in the water as it flows back down to the ocean. When this water evaporates from the ocean, the salt stays behind. This has been going on for more than a billion years. That is why the ocean is now very salty.

From Plain Talk About Drinking Water: Questions and Answers About the Water You Drink by Dr. James M. Symons, published by American Water Works Association.

Water Facts of Life

"Ride the Water Cycle" with these fun facts.

- There is the same amount of water on Earth as there was when the Earth was formed. The water from your faucet could contain molecules that dinosaurs drank.
- Water is composed of two elements, Hydrogen and Oxygen. 2 Hydrogen + 1 Oxygen = H_2O.
- Nearly 97% of the world's water is salty or otherwise undrinkable. Another 2% is locked in ice caps and glaciers. That leaves just 1% for all of humanity's needs — all its agricultural, residential, manufacturing, community, and personal needs.
- Water regulates the Earth's temperature. It also regulates the temperature of the human body, carries nutrients and oxygen to cells, cushions joints, protects organs and tissues, and removes wastes.
- 75% of the human brain is water and 75% of a living tree is water.
- A person can live about a month without food, but only about a week without water.
- Water is part of a deeply interconnected system. What we pour on the ground ends up in our water, and what we spew into the sky ends up in our water.
- The average total home water use for each person in the U.S. is about 50 gallons a day.
- The average cost for water supplied to a home in the U.S. is about $2.00 for 1,000 gallons, which equals about 5 gallons for a penny.
- Water expands by 9% when it freezes. Frozen water (ice) is lighter than water, which is why ice floats in water.

THE BLUE THUMB QUIZ

BLUE THUMB

Give drinking water a hand.

Here are 20 quick questions to find out if you know how to give drinking water a hand.

Mark the following true or false and compare your answers with those on the back of this sheet.

TRUE FALSE

☐ ☐ **1.** Installing a low-flow toilet can save a family of four more than 45 gallons of water a day.

☐ ☐ **2.** More than 75 percent of the water in the United States is located underground.

☐ ☐ **3.** Reading the labels on common household products won't tell you what products are harmful to water.

☐ ☐ **4.** Americans improperly dispose of more oil in a year than the Exxon Valdez spilled.

☐ ☐ **5.** Even when a recipe calls for using warm or hot water, you should draw cold water from the tap and heat it on the stove or in the microwave.

☐ ☐ **6.** It's safe to drink water directly from remote streams.

☐ ☐ **7.** There are ways to landscape that use between 30 - 80 percent less water than traditional landscaping.

☐ ☐ **8.** If you have your own well, you can be sure your water is safe.

☐ ☐ **9.** You can drink more than 4,000 eight-ounce glasses of tap water for the same cost as a six-pack of soda pop.

☐ ☐ **10.** Common outdoor bug and weed killers can contaminate underground water or end up in your local river or lake.

☐ ☐ **11.** The quality of U.S. drinking water is not regulated by the federal government for safety.

☐ ☐ **12.** Two-thirds of the water you use at home you use in the bathroom.

☐ ☐ **13.** Trash and debris around a lake won't affect water quality.

☐ ☐ **14.** It's better for water if you dry out leftover household products such as furniture polish, car wax, or latex paint, before disposing of them.

☐ ☐ **15.** More than 800,000 new water wells are drilled each year for domestic, commercial, and industrial use.

☐ ☐ **16.** Letting the water run while you brush your teeth or shave is water wise.

☐ ☐ **17.** New water sources are being discovered every day.

☐ ☐ **18.** An abandoned well can be left unsealed without jeopardizing the groundwater source.

☐ ☐ **19.** You can ignore a leaky faucet at work or at school... it's only worth saving water at home.

☐ ☐ **20.** You can influence decisions your community makes on drinking water.

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1. True. That's 1,350 gallons a month!

2. True. However, 50 percent of U.S. drinking water is from surface sources.

3. False. Don't buy products that say "poisonous, toxic, corrosive," etc.

4. True.

5. True. Heat can dissolve lead from pipes and solder into your water. New houses with lead-free solder are not as likely to have lead problems.

6. False. Giardiasis can be caused by animal wastes in remote untreated streams.

7. True. It's called Xeriscape™.

8. False. Contaminants can seep through the ground — have your well tested for contaminants by your local Health Department.

9. True. In some cities, the number of glasses can go as high as 15,000.

10. True. They can seep into the water under ground or rain can wash them into surface water.

11. False. The U.S. government regulates quality and currently has standards for more than 80 contaminants.

12. True. Showers and toilets are the major users.

13. False.

14. True. Even though some landfills have a protective lining, leakage can occur and contaminate groundwater.

15. True. Many are drilled to monitor water quality in aquifers and in areas around dump sites.

16. False. It wastes water.

17. False. We have identified or are using most water sources in the U.S.

18. False. All unused wells should be capped. Open wells can provide a route for contaminants to reach aquifers.

19. False. It's smart to save water no matter where you are.

20. True. Call your water utility company, speak up at public meetings, write a letter to your City Council — you can affect decisions!

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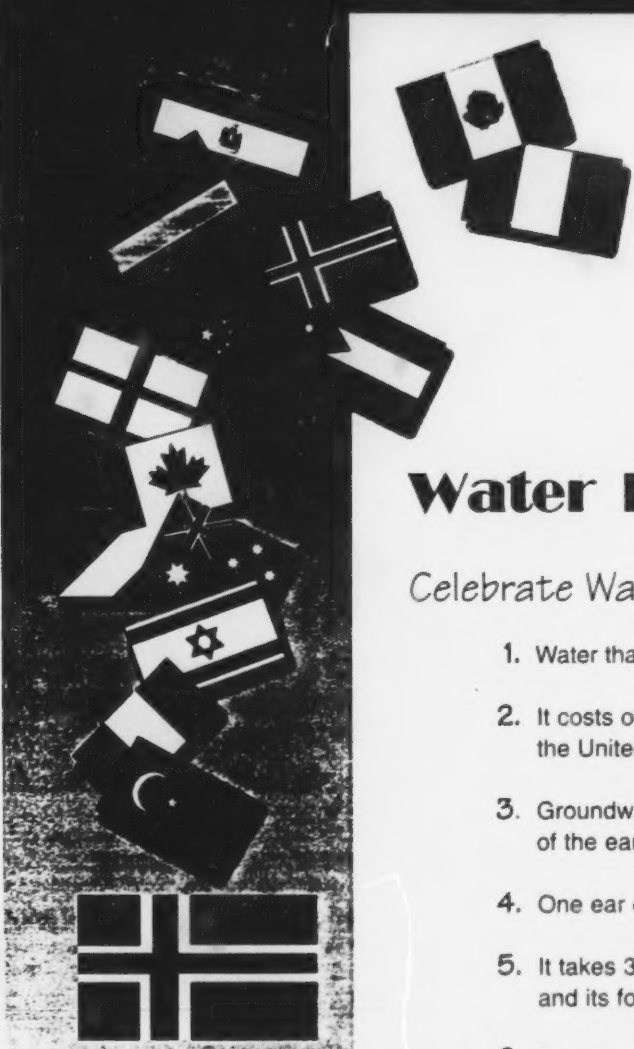

Water Facts of Life

Celebrate Water with these fun facts.

1. Water that is safe to drink is called potable (pronounced pó'ta-bal).
2. It costs over $3.5 billion to operate water systems throughout the United States each year.
3. Groundwater is water that sinks into the upper portion of the earth's surface.
4. One ear of corn is 80% water.
5. It takes 39,090 gallons of water to manufacture a new car and its four tires.
6. For the price of a single can of soda—an average 50 cents—many communities deliver up to 1,000 gallons of fresh, clean drinking water to homes.
7. Each year, nearly 10,000 cubic miles of water flows along the world's rivers to the oceans.
8. Public water suppliers in the US process nearly 34 billion gallons of water per day for domestic and public use.
9. On average, 50%–70% of household water is used outdoors for watering lawns and gardens.
10. Americans drink more than 1 billion glasses of tap water per day.

The word walrus comes from Iceland by way of Scandinavia. In Icelandic, this animal is called a hross-hwair, meaning a "horse whale" because of its horselike neighing. In Scandinavia, the name became "whale horse" or "walrus" in English.

Blue Thumb Tips and Tricks

Get involved and use these Blue Thumb Tips and Tricks to help conserve and protect water, our most precious natural resource.

Tip: Recycle water from fish tanks.

Trick: Use it to water plants. Fish emulsion is a good, inexpensive fertilizer high in nitrogen and phosphorous.

Tip: Check faucets for leaks.

Trick: Do-it-yourself and replace worn washers periodically.

Tip: Promote water pollution prevention in your neighborhood.

Trick: Organize the cleanup of a river, lake, stream, or canal in your community.

Tip: When watering the lawn, avoid watering the house, sidewalk, or street.

Trick: Adjust sprinklers so only the lawn is watered.

Tip: Don't let the tap run every time you want a drink.

Trick: Fill a pitcher with tap water and put it in the fridge.

Tip: Never pour toxic chemicals down the drain, on the ground, or in the trash.

Trick: Choose natural household cleaners like borax, ammonia, vinegar, and baking soda and recycle hazardous household waste at waste collection centers.

Tip: Promote water conservation by watering trees and plants only once a week.

Trick: Place a layer of mulch around trees and plants to retain water.

Tip: Know how often your lawn needs watering.

Trick: Use a moisture indicator to tell when your lawn needs watering and when it doesn't.

Tip: Get involved and voice your opinion about water issues in your community.

Trick: Attend a water board or planning commission meeting.

The Chinese discovered the purifying effects of boiling water.

Be Hydro-Logical

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ACTION: Turn off the water when you brush your teeth and shave. Install low-flow toilets, shower heads and faucet aerators and you'll save thousands of gallons/liters of water a year. It's a savings that should reduce your water bill.

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ACTION: If you own a well, contact your local health department or Cooperative Extension Service representative to find out how to test the quality of your well water.

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ACTION: Call your water utility and ask for a copy of their latest water quality report.

EPA
United States
Environmental Protection
Agency
Office of Water
4601
EPA 810-F-95-001
April 1995

WATER TRIVIA FACTS

1. How much water does it take to process a quarter pound of hamburger?
   Approximately one gallon.
2. How much water does it take to make four new tires?
   2,072 gallons
3. What is the total amount of water used to manufacture a new car, including new tires?
   39,090 gallons per car
4. How many households use private wells for their water supply?
   17,000,000 households
5. Water is the only substance found on earth naturally in the three forms.
   True (solid, liquid, and gas)
6. Does water regulate the earth's temperature?
   Yes (it is a natural insulator)
7. How long can a person live without food?
   More than a month
   How long can a person live without water?
   Approximately one week, depending upon conditions.
8. How much water must a person consume per day to maintain health?
   2.5 quarts from all sources (*i.e.*, water, food)
9. How much water does a birch tree give off per day in evaporation?
   70 gallons
10. How much water does an acre of corn give off per day in evaporation?
    4,000 gallons
11. How many miles of pipeline and aqueducts are in the US and Canada?
    Approximately one million miles, or enough to circle the earth 40 times
12. What were the first water pipes made from in the US?
    Fire charred bored logs
13. How much water is used to flush a toilet?
    2-7 gallons
14. How much water is used in the average five-minute shower?
    25-50 gallons
15. How much water is used to brush your teeth?
    2 gallons
16. How much water is used on the average for an automatic dishwasher?
    9-12 gallons

17. On the average, how much water is used to hand wash dishes?
    20 gallons

18. How many community public water systems are there in the United States?
    56,000

19. How much water do these utilities process daily?
    34 billion gallons

20. Of the nation's community water supplies, how many are investor-owned?
    32,500

21. How much water does the average residence use during a year?
    107,000 gallons

22. How much water does an individual use daily?
    50 gallons

23. What does a person pay for water on a daily basis?
    National average is 25 cents

24. How much of the earth's surface is water?
    80%

25. Of all the earth's water, how much is ocean or seas?
    97%

26. How much of the world's water is frozen and therefore unusable?
    2%

27. How much of the earth's water is suitable for drinking water?
    1%

28. Is it possible for me to drink water that was part of the dinosaur era?
    Yes

29. If all community water systems had to be replaced, what would it cost?
    In excess of $175 billion

30. What does it cost to operate the water systems throughout the country annually?
    Over $3.5 billion

31. How much does one gallon of water weigh?
    8.34 pounds

32. How many gallons of water would it take to cover one square mile with one foot of water?
    219 million gallons

33. How much water is in one cubic foot?
    7.84 gallons

34. How many gallons of water do you get per acre, when it rains one inch?
    27,000 gallons per acre

35. At what temperature does water freeze?
    32 degrees F, 0 degrees C

36. At what temperature does water vaporize?
    212 degree F, 100 degrees C

37. What is the most common substance found on earth?
Water

38. How much of the human body is water?
66%

39. How much of a chicken is water?
75%

40. How much of a pineapple is water?
80%

41. How much of a tomato is water?
95%

42. How much of an elephant is water?
70%

43. How much of an ear of corn is water?
80%

44. How much water does it take to process one chicken?
11.6 gallons

45. How much water does it take to process one can of fruit or vegetables?
9.3 gallons

46. How much water does it take to process one barrel of beer?
1,500 gallons

47. How much water does it take to make one board foot of lumber?
5.4 gallons

48. How much water does it take to make one pound of plastic ?
24 gallons

49. How much water does it take to make one pound of wool or cotton?
101 gallons

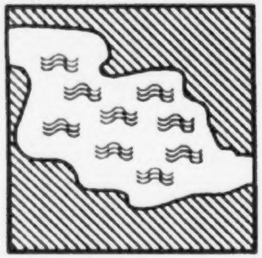
50. How much water does it take to refine one barrel of crude oil?
1,851 gallons

51. How much does it take to produce one ton of steel?
62,600 gallons

52. How much water does it take to process one ton of cane sugar to make processed sugar?
28,100 gallons

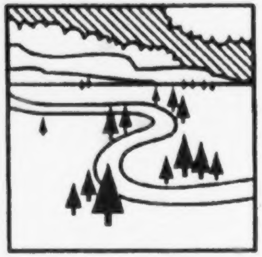
53. How much water does it take to process one ton of beet sugar to make processed sugar?
33,100 gallons

The Decision Process for Drinking Water.



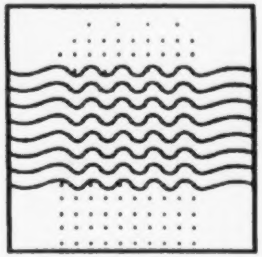
Source

- Does the drinking water come from lakes, rivers, or wells?
- How clean is the source?
- How much is there?
- How do we finance it?
- How do we protect it?
- What type of recreational uses are appropriate?



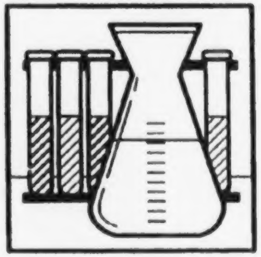
Transport

- How far must the water travel?
- Over what type of land?
- What is the cost to move it?



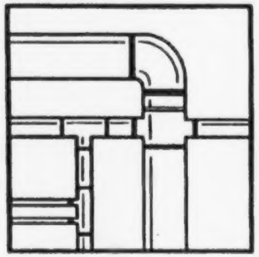
Treatment

- What type of treatment does the water need?
- Are the facilities adequate?
- How do we finance treatment?
- Is more research needed?



Testing

- What federal and state tests are required?
- How safe is the water?
- What must the public be told?



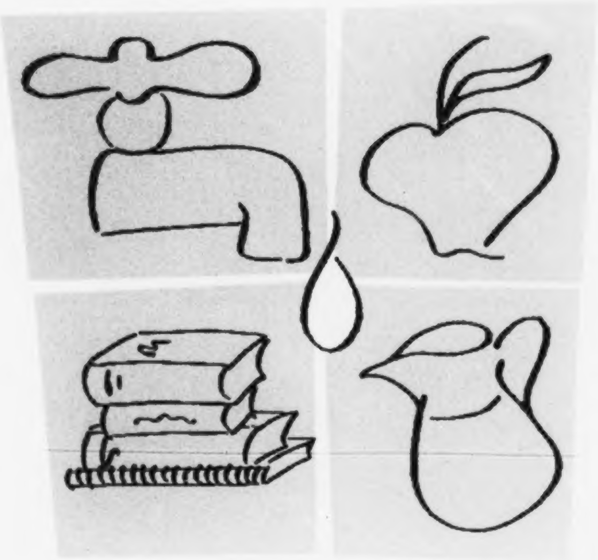
Delivery

- Where must the water go?
- Is the delivery system adequate?
- Does the system allow the community to grow?
- How is the system financed?

Home

- Do you ever run out of water?
- Do you have lead pipes or solder?
- Do you know how to reduce lead in your water?
- Do you waste water?
- How much do you valu your water?

Science Projects



United States
Environmental Protection
Agency

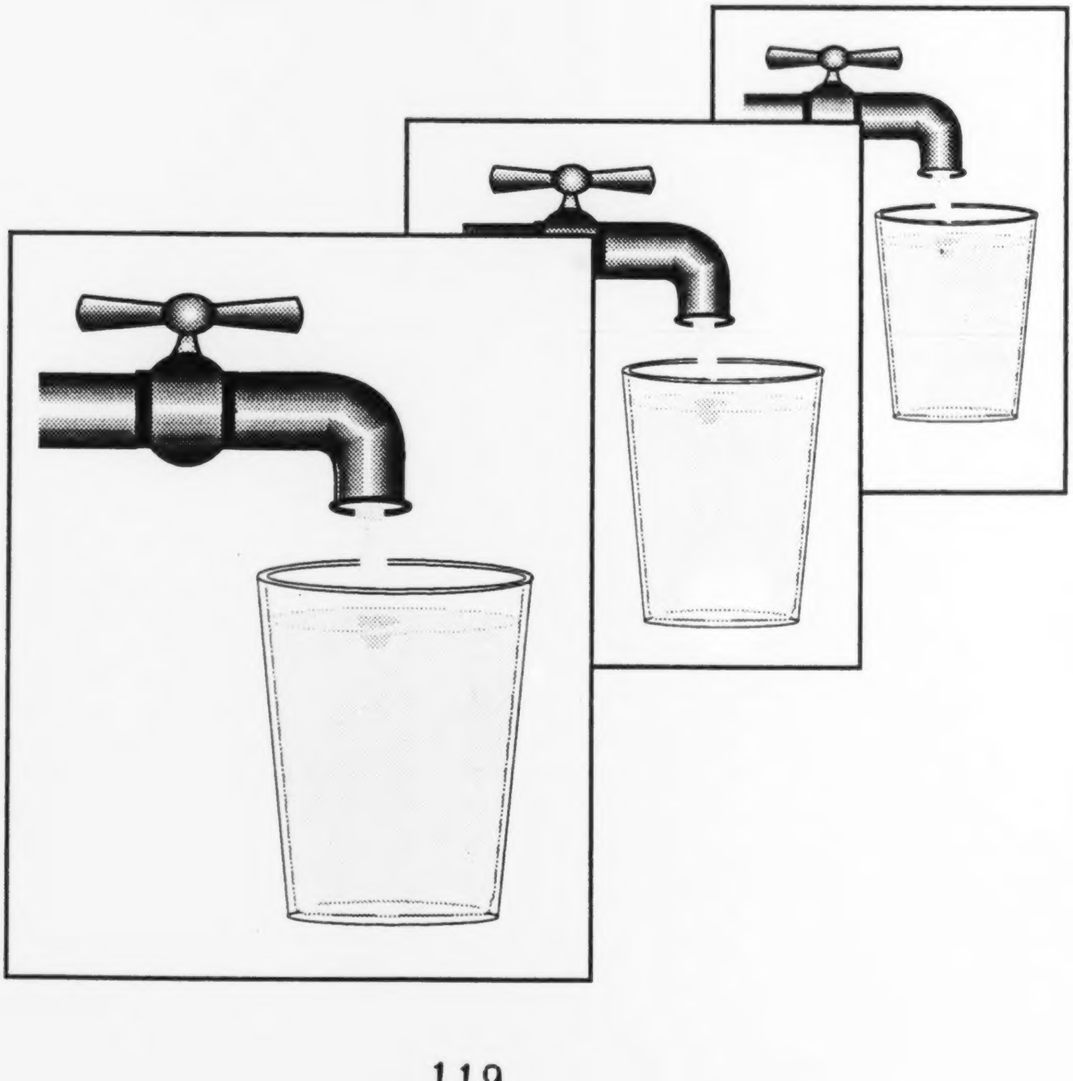
Office of Water
4601

EPA 570/9-90-007
April 1990

EPA

Science Demonstration Projects in Drinking Water

(Grades K-12)



introduction

This pamphlet includes a brief selection of science demonstration projects related to drinking water for K-12 students. The projects are organized according to the following grade categories: primary (K-4); middle/junior high (5-8); and secondary (9-12). The divisions between grade categories are arbitrary. The projects are essentially applicable to all grade levels. By simply varying the vocabulary and expanding or contracting the background and discussion sections, each project can be made relevant to a specific grade level.

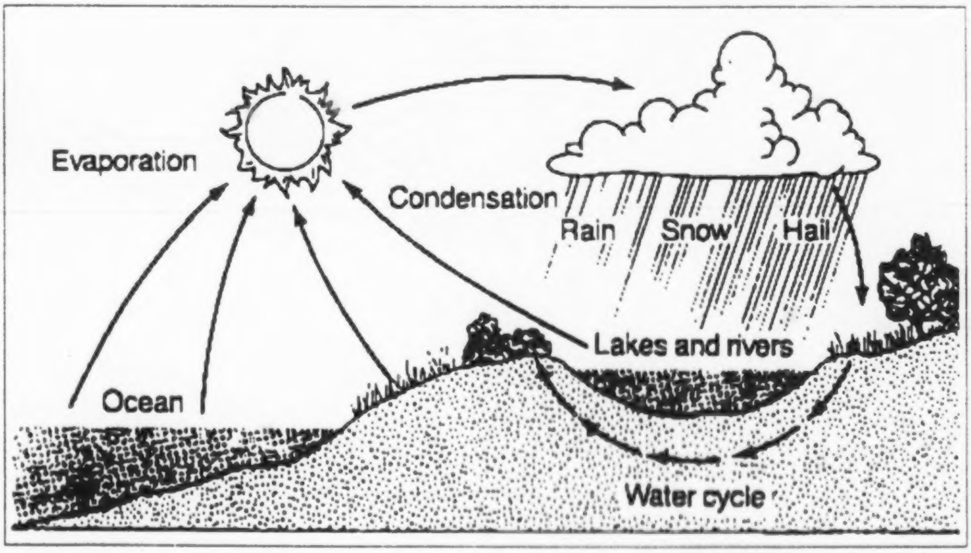
The general areas covered by the demonstration projects include the chemical/physical aspects of water, contamination and treatment of drinking water, distribution and supply of drinking water, and water conservation. While the projects presented are complete activities, teachers are encouraged to expand the projects to meet the needs and goals of their respective teaching situations.

The demonstration projects included in this pamphlet are representative of many such projects developed by talented professionals in the science, engineering, and education communities. The projects have been reprinted in whole or in part with the permission of the appropriate publishers. Reference and/or credit information is included with each activity. In addition, a list of organizations that have developed or are developing projects related to drinking water are included at the back of this document.

The Never Ending Cycle of Water

Background

Water is very abundant on Earth. It circulates continuously between the air, the ground, and plants and animals. This constant circulation of water is known as the *water cycle*. Water is carried through air where it eventually **condenses** into small droplets which form clouds. From the clouds, water falls to the Earth in the form of rain or snow **(precipitation)**. This water is absorbed into the ground or runs over the surface of the ground into rivers and lakes. Plants and animals use the water to live. Water then **evaporates** from soil, the leaves of plants, the lungs and skin of animals, and from the surface of puddles, streams, and lakes to the air.



Source: *Science Activities for Children*

Objective

To demonstrate that water moves in a continuous cycle.

Materials

Large, wide-mouthed clear glass jar

*Gravel**

*Sphagnum or peat moss**

*Soil**

Woodland plants (e.g., violets, ferns, or mosses—gathered in backyards or available from nurseries)

Water

Light source or a sunny window sill

Tight-fitting jar lid (or plastic wrap secured by rubber band or masking tape)

Procedure

1) Place a one-inch layer of gravel on the bottom of the clear glass jar. Cover this layer with one of sphagnum or peat moss, followed by a layer of soil (see illustration at right).
2) Set woodland plant(s) into the soil mixture.
3) Water terrain lightly.
4) Cover glass jar tightly with lid (if available) or with plastic wrap secured by a rubber band or masking tape and place under or near a light source.
5) Observe the glass jar over several hours.

Discussion

1) What collected on the sides of the glass jar? (condensed moisture)

2) Where did the moisture on the sides of the glass jar come from? (evaporated water from plants)

3) What provided the energy for the changes observed in the water's form? (the sun)

Suggested Activities

Prior to conducting this activity, the teacher may wish to more fully demonstrate the processes of precipitation, evaporation, and condensation. In addition, a discussion or demonstration of water in its three states (solid, liquid, gas) might also be useful. Samples of such experiments can be found in the source material noted below.

**(available from hardware stores or nurseries)*

Sources

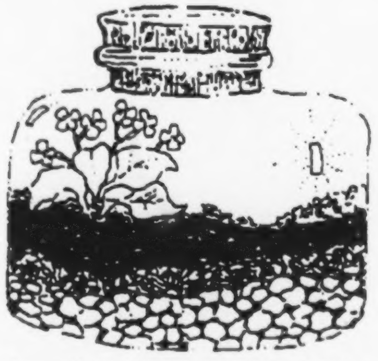
Background information adapted with permission from:

Willard J. Jacobson and Abby B. Bergman. *Science Activities for Children*. (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1983). p. 47.

Activity adapted with permission from:

Water Wizards. (Boston, MA: Massachusetts Water Resources Authority. 1983). pp. 2-4.

"Water: We Can't Live Without It." *National Wildlife Week Educators' Guide*. (Washington, DC: National Wildlife Federation, March 18-24, 1984). p. 7.



Source: *National Wildlife Week Educators' Guide*

How People Get Their Water

Background

Nearly 80 percent of the Earth's surface is water, yet less than one percent can be used for drinking water. Water moves in a continuous cycle between the air, the ground, and plants and animals (see previous activity). Most water does not naturally exist in a pure form or in a form that is safe for people to drink. Consequently, water must be cleaned prior to consumption. Water utilities provide such treatment before water is sent through pipes to homes in the community.

The demand for water by people varies. The availability of water also varies in different areas of the country. Consequently, utilities store extra water in spaces known as **reservoirs**. Water is usually contained in reservoirs by a dam. Reservoirs help ensure that communities do not run out of water at any given time regardless of the communities' total water use.

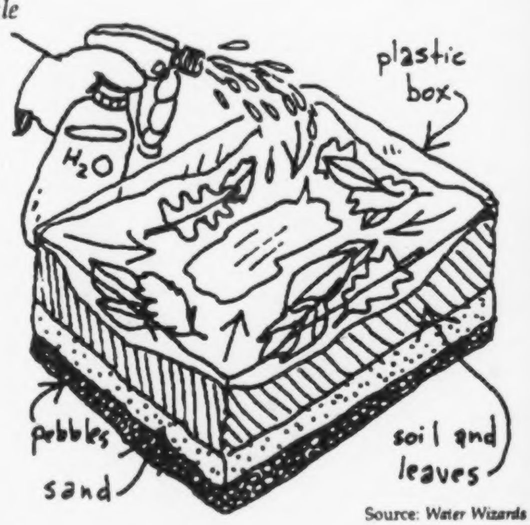
Activity #1

Objective

To illustrate how a reservoir works.

Materials

Plastic box
Spray bottle
Pebbles
Soil
Sand
Leaves



Source: *Water Wizards*

Procedure

1) Construct a model of a reservoir using a clean, clear plastic box (see illustration). Line the bottom of the box with small pebbles and then layer sand, soil, and leaves on top (sloping the material downward toward the edges of the box).
2) Carefully spray water on the four corners of the model until the soil mixture is saturated and the water has seeped through to the open area—the reservoir.

Discussion

1) What are the sources of water for a reservoir? (precipitation in the form of rain and snow)
2) How does water get into a reservoir? (It seeps over and through the soil above the reservoir.)
3) What contains or holds water in a real reservoir? (dams)
4) What kind of treatment does water receive in a reservoir? (natural filtration through leaves, grass, and soil; also some settling occurs in the reservoir)

primary

Activity #2

Objective

To build a model of a water delivery system from source to user.

Materials

Large piece of paper or cardboard

Paper towel tubes

Different sizes of pasta (linguini, spaghetti, manicotti)

Glue

Reservoir built in Activity #1 (optional)

Procedure

1) Using the pasta and paper towel tubes, create a community pipe system (see illustration). Connect the "pipes" with glue and lay out on the large sheet of paper or cardboard.

2) Either use the reservoir constructed in the previous activity or draw one on the cardboard; also draw houses, schools, and other buildings that receive water from the delivery system.

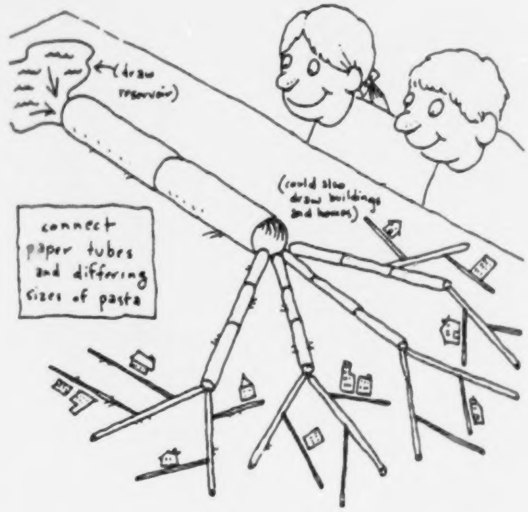
Discussion

Students should consider how water gets from reservoirs to distribution systems and to individual homes. (The circumference of pipes decreases as the distribution system expands into the community. As water travels through a distribution system, it is continuously diverted down different pathways. These pathways lead to individual homes and businesses. The circumference of a pipe determines the quantity of water that can be contained in the pipe at any one time and determines, in part, the rate at which the water will travel through the pipe. As the distribution system expands to homes and businesses, the volume of water needed per home or business represents only a portion of the total volume leaving the treatment plant. Consequently, smaller pipes are needed in these areas of the distribution system, whereas larger pipes are needed near the treatment plant. Water treatment plants generally pump water from the reservoir to holding or water towers. The water flows by gravitational force from the water tower and throughout the distribution system.)

Source

Activities adapted with permission from:

Water Wizards. (Boston, MA: Massachusetts Water Resources Authority, 1983). pp. 10-14.


(draw reservoir)
(could also draw buildings and homes)
connect paper tubes and differing sizes of pasta

Source: *Water Wizards*

Conserving Water for The Future

Background

Water is very valuable to us. We all need approximately 2 liters of water each day. We can live several weeks without food, but can only live several days without water. Water makes up our body's blood (which is 83% water), transports bodily wastes, and helps us digest our food. We get most of our body's daily requirement of water from food. But water is a limited resource, which means that there is only so much water on Earth available for use. In order for water to be available when needed, it must be conserved.

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Objective

To emphasize the need for water conservation.

Materials

One 12 ounce clear glass

Water

Question and answer sheet for each student

Procedure

1) Explain to the students that they are conducting an experiment that will test what it is like to not have a drink of water. Inform the students that they may not drink water the entire morning or afternoon preceding the conclusion of the activity.

2) Place the glass of water on a desk in the front of the classroom to visually remind students of water.

3) About one half-hour before lunch or the conclusion of the school day, provide students with the following questions to answer individually or as a group.

Discussion

1) An average glass can hold 12 ounces of a liquid such as water. An average drip from a sink can waste 5 gallons of water per day or 240 ounces per day. How many glasses of water could be saved per day by fixing the leak? (Answer: 20)

2) An average bathtub uses 36 gallons of water while the average short shower uses only 25 gallons — a difference of 11 gallons or 1408 ounces. Approximately how many glasses of water could be saved if a person took a short shower instead of a bath? (Answer: 117.3)

3) Do you think that some glasses of water could be saved if people filled dishwashers or washing machines with partial rather than full loads? (No. Most dishwashers and washers use the same amount of water, no matter if there is a full or partial load; in some models the cycle can be changed.)

4) What other conservation measures can you think of that would save glasses of water? (Answers will vary.)

5) How thirsty do you feel after not receiving water the entire morning or afternoon? (Answers will vary.)

6) How do you think you would feel if you could only have several ounces of water each day? (Very thirsty, sick, and eventually dead.)

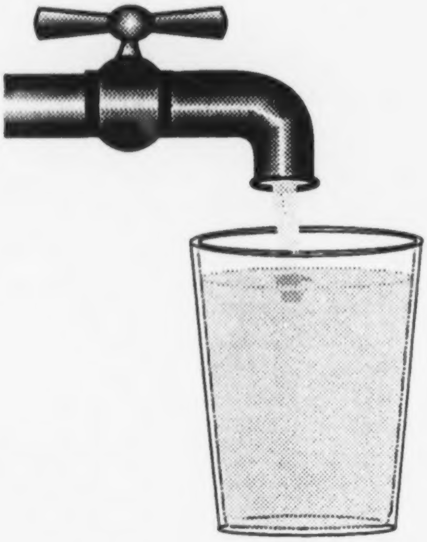
Suggested Activities

Many other activities can teach students about water conservation, including "water audits" of personal, family, and even school-wide water use. A variation of the "Water Use Analysis" project presented later in this pamphlet may be appropriate to demonstrate how people use water differently. A discussion of how various cultures (e.g., desert versus city dwellers) value water as well as spend time and effort obtaining it might also be useful.

Source

Activity adapted with permission from:

Water and Water Conservation Curriculum. (Aurora, CO: Aurora Utilities Department). p. 197.



How Substances are Measured in Water

Background

We often find references to parts per million, parts per billion, and even parts per trillion in our everyday reading and news reports. What do they mean? Most of us have difficulty imagining large numbers of objects. How many stars can you see in the clear night sky far away from the smog and lights of the city? What does it mean when we read that an insecticide has been found in our groundwater at a concentration of 5 parts per billion? Developing an understanding of extremely large and extremely small numbers is very difficult.

Objective

To visualize the concept of extremely small numbers.

Material

1 bottle of food coloring

1 medicine dropper

1 white egg carton (6 or 12 eggs) or six small clear plastic cups

2 other containers to hold food coloring and water

Procedure

1) Prior to conducting the activity, ask students to consider the following:
   a) What is the largest number of things you can clearly visualize in your mind? [Most of us can handle 5, 10, perhaps even 20 if we use all of our fingers and toes.]
   b) Can you visualize a group of 100 people? [Many people think they can by describing a party or community meeting. If you try to visualize a group of 80 or 120 differently from the 100, it soon becomes apparent that our visualization is not that clear. The Rose Bowl full of people represents about 100,000. Trying to pick out just 1 individual in that crowd would be finding 1 in 100,000.]
   c) Food coloring from the store is usually a 10% solution. What does 10% mean? [It means 10 parts (by weight) of solid food coloring dye is dissolved in 100 parts (by weight) of solution. For example, 10 grams of dye dissolved in 90 grams of water make a total of 100 grams of 10% solution.]
2) Put some food coloring (5 or 6 drops from the bottle) into one small container and some tap water into the other.
3) Use the medicine dropper to place one drop of 10 percent food coloring (as it comes from the store) into the first container. [Since 10% means 10 parts of food coloring per 100 parts of solution, it is the same as 1 part food coloring in 10 parts of solution.]
4) Use the medicine dropper to add 9 drops of water to the first container. Stir well. What is the concentration of the food coloring? [You have 1 drop of the original food coloring in 10 drops of the new solution. Thus the concentration of the new solution is 1/10 of the original. The original was 1 part in 10, so the concentration of the food coloring is now 1/10 of 1 part in 10. This is 1 part in 10 x 10, **or 1 part of food coloring in 100 parts of solution.]**
5) Use the medicine dropper to transfer 1 drop of solution to the next container. Add 9 drops of water. Mix. You have again changed the concentration by a factor of one-tenth. What is the food coloring concentration in this container? [1/10 of 1 part in 100 is 1 part in 10 x 100, **or 1 part in 1000 parts of solution.]**
6) Transfer one drop of the 1 part in 1000 parts of solution into the next container. Add 9 drops of water. Mix. What is the concentration? [1 part in 10,000 parts of solution.]
7) Continue to dilute 1 drop of each solution by adding water as before to obtain 1 part in 100,000 and then 1 part in 1,000,000. Your final solution is **one part per million.**

Discussion

1) In which cavity do you first observe no visual evidence that food coloring is present? [This generally occurs in the final container, which is 1 ppm of food coloring.]
2) Since you cannot see any color present, how do you know there is indeed food coloring present?
3) Can you think of an experiment that you could do to prove there is food coloring present in each cup? Do it.

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4) Which is more concentrated, one part per million or 200 parts per billion? [A billion is a thousand million. Therefore, 1 ppm is 1000 ppb. 1 ppm is more concentrated than 200 ppb.]

Sources

Activity adapted with permission from:

Chemicals in Society Participant's Guide. (Berkeley, CA: Chemical Education for Public Understanding Program, University of California at Berkeley, 1989). pp. 5-6.

Conserving the Nation's Water Resources

Background

People require an average of 2 L of water per day to sustain life. However, the average American uses about 100 times more water than this every day at home. An average family of four in the United States might use about 900 L of water per day for the purposes identified in the table below.

Approximate daily water use by a family of four in the U.S.

Use	Liters per Day
Drinking and cooking	30
Dishwasher (3 loads per day)	57
Toilet (16 flushes per day)	363
Bathing (4 baths or showers per day)	303
Laundering clothes	130
Watering houseplants	4
Rinsing garbage into disposal unit	13
Total daily use:	**900 L**

(A reminder: 1 gallon = 3.8 L; 26.3 gallons = 100 L. The total daily water use of 900 L is equal to about 237 gallons.)

Source: *Earth: The Water Planet*

Objective

To provide a real-life model of how much water a family typically uses on a daily basis; to allow participants to experience firsthand how much effort is required to transport water; and to illustrate that when people desire, they can sharply reduce their water usage.

Materials

A schoolyard or large room with a water source
Two 122 L (32 gallon) trash cans
Empty milk jugs and/or buckets (as many as possible)
100 L of water
A watch or clock with a second hand
A meter stick (optional)

The story begins:

One cold January, the Smith family rent a house in the mountains for a ski vacation. The house, though old, has all the comforts of home — three bathrooms, a complete laundry room, dishwasher, and garbage disposal, plus a newly installed solar hot water heating system. Unfortunately, the weather gets so cold one night that a water main in town breaks, and the Smiths find out that the house will have no water service from the local utility for the entire week. What should they do — go back home or try to find another water supply?

Mr. Smith learns from a neighbor that there is an unfrozen spring 100 m from the house that could still be used for drinking water. Mrs. Smith, who is a mechanical engineer, discovers that if the municipal water line coming into the house were shut off, the water in the storage tank for the solar water heater could be routed directly into the plumbing system. The water system in the house will work as long as the storage tank is kept filled with water from the spring.

Mr. and Mrs. Smith discuss the situation with their two children Alice (14) and Sam (12). The family decides to form a "family bucket brigade" from the spring to the house, fill the storage tank each day, and continue their vacation. The storage tank can hold about 900 L of water.

Procedure

1) Place the two trash cans 100 m apart (measure with a meter stick or the distance is equal to approximately 150 paces for an average size adult).

2) Place 100 L of water in one of the trash cans. This can will represent the spring.

3) Select four students to represent the Smith family; equip each person with as many buckets and milk jugs as he/she can carry; and have students transfer the 100 L of water from the spring to the house (the house being represented by the second trash can located 100 m away).

4) Have students record the time when the Smith family begins and finishes carrying the first 100 L of water. Students should then determine the total time that was required for the Smith family to transfer all of the water.

5) The Smiths may feel a little tired after transferring the 100 L of water. Thus far, they have only carried 11 percent of the water required to fill the tank. They still have 800 L to go. To save water (since this is role playing), have the Smiths bring the same 100 L back from the house to the spring rather than getting additional water out of the faucet being used.

6) The Smiths should continue carrying the water back and forth until the 100 L of water has changed cans a total of nine times, and the Smiths have carried the equivalent of 900 L of water 100 m to the house.

7) Have students record the time when the Smiths finish moving the entire 900 L of water from the spring to the house. Ask students the total amount of time (probably will be about 30 minutes) that was required to move the 900 L of water.

The story continues:

After carrying all of the water, the Smiths are too tired to ski very much. They come home early, have spaghetti for lunch, wash the dishes, and launder their bucket brigade clothes (which got muddy at the spring). After eating dinner, washing more dishes and clothes, watering the houseplants, and taking long, hot showers, they go to bed.

It is snowing too hard the next day to ski, so the Smiths stay in the house all day. When Mr. Smith tries to start the dishwasher after lunch, he discovers that the family is out of water! Sam and Alice groan and say that they would rather be grounded until they are 21 than carry 900 L of water to the house every day. They point out that they haven't even been in the house a full 24 hours since previously carrying the water.

Discussion

Have students identify and defend water conservation measures. What steps could the Smiths have taken to conserve water and save their ski vacation? (Some conservation measures include washing clothes less frequently, running the dishwasher once per day, fixing any leaking plumbing fixtures, taking quick showers, not flushing toilets after every use, reducing the amount of water required for toilet flushing, etc.)

Source

Activity adapted with permission from:

Jack E. Gartrell, Jr., Jane Crowder, and Jeffrey C. Callister. *Earth: The Water Planaet*. (Washington, DC: The National Science Teachers Association, 1989). pages 85-89.

How Water Is Cleaned

Background

Water in lakes, rivers, and swamps often contains impurities that make it look and smell bad. The water may also contain bacteria and other microbiological organisms that can cause disease. Consequently, water from surface sources must be "cleaned" before it can be consumed by people. Water treatment plants typically clean water by taking it through the following processes: 1) **aeration;** 2) **coagulation;** 3) **sedimentation;** 4) **filtration;** and 5) **disinfection.** Demonstration projects for the first four processes are included below.

Objective

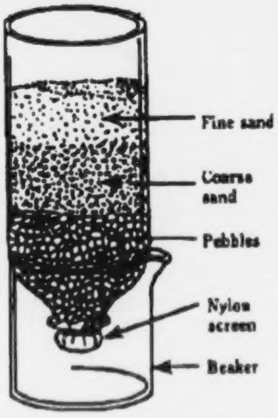
To demonstrate the procedures that municipal water plants use to purify water for drinking.

Materials

5 L of "swamp water" (or add 2 1/2 cups of dirt or mud to 5 L of water)

One 2 L plastic soft drink bottle with its cap (or cork that fits tightly into the neck of the bottle)

Two 2 L plastic soft drink bottles — one bottle with the top removed and one bottle with the bottom removed



Source: *Earth: The Water Planet*

One 1.5 L (or larger) beaker or another soft drink bottle bottom

20 g of alum (potassium aluminum sulfate — approximately 2 tablespoons; available at a pharmacy)

Fine sand (about 800 ml in volume)

Coarse sand (about 800 ml in volume)

Small pebbles (about 400 ml in volume)

A large (500 ml or larger) beaker or jar

A small (approximately 5 cm x 5 cm) piece of flexible nylon screen

A tablespoon

A rubber band

A clock with a second hand or a stopwatch

Procedure

1) Pour about 1.5 L of "swamp water" into a 2 L bottle. Have students describe the appearance and smell of the water.

2) **Aeration** is the addition of air to water. It allows gases trapped in the water to escape and adds oxygen to the water. Place the cap on the bottle and shake the water vigorously for 30 seconds. Continue the aeration process by pouring the water into either one of the cut-off bottles, then pouring the water back and forth between the cut-off bottles 10 times. Ask students to describe any changes they observe. Pour the aerated water into a bottle with its top cut off.

3) **Coagulation** is the process by which dirt and other suspended solid particles are chemically "stuck together" into floc so that they can be removed from water. With the tablespoon, add 20 g of alum crystals to the swamp water. Slowly stir the mixture for 5 minutes.

4) **Sedimentation** is the process that occurs when gravity pulls the particles of floc (clumps of alum and sediment) to the bottom of the cylinder. Allow the water to stand undisturbed in the cylinder. Ask students to observe the water at 5 minute intervals for a total of 20 minutes and write their observations with respect to changes in the water's appearance.

5) Construct a filter from the bottle with its bottom cut off as follows (see illustration at left):

   a) Attach the nylon screen to the outside neck of the bottle with a rubber band. Turn the bottle upside down and pour a layer of pebbles into the bottle — the screen will prevent the pebbles from falling out of the neck of the bottle.

   b) Pour the course sand on top of the pebbles.

   c) Pour the fine sand on top of the course sand.

   d) Clean the filter by slowly and carefully pouring through 5 L (or more) of clean tap water. Try not to disturb the top layer of sand as you pour the water.

6) **Filtration** through a sand and pebble filter removes most of the impurities remaining in water after coagulation and sedimentation have taken place. After a large amount of sediment has settled on the bottom of the bottle of swamp water, carefully — without disturbing the sediment — pour the top two-thirds of the swamp water through the filter. Collect the filtered water in the beaker. Pour the remaining (one-third bottle) of swamp water into the collection bucket. Compare the treated and the untreated water. Ask students whether treatment has changed the appearance and smell of the water. [Inform students that a water treatment plant would as a final step disinfect the water (e.g., would add a disinfectant such as chlorine gas) to kill any remaining disease-causing organisms prior to distributing the water to homes. Therefore, the demonstration water is not safe to drink.]

Discussion

1) What was the appearance of the swamp water? (Answers will vary, depending on the water source used. Water from some sources may be smelly and/or muddy.)

2) Does aeration change the appearance or smell of water? (If the original water sample was smelly, the water should have less odor after aeration. Pouring the water back and forth allows some of the foul-smelling gases trapped to escape to the air of the room. Students may have observed small bubbles

suspended in the water and attached to the sides of the cylinder.)

3) How did the sedimentation process effect the water's appearance? Did the appearance of the water vary at each 5 minute interval? (The rate of sedimentation depends on the water being used and the size of alum crystals added. Large particles will settle almost as soon as stirring stops. Even if the water contains very fine clay particles, visible clumps of floc should form and begin to settle out by the end of the 20-minute observation period.)

4) How does the treated water (following filtration) differ from the untreated swamp water? (After filtration, the treated swamp water should look much clearer than the untreated water. It probably will not be as clear as tap water, but the decrease in the amount of material suspended in the water should be quite obvious. The treated sample should have very little odor when compared to the starting supply of swamp water.)

Suggested Activities

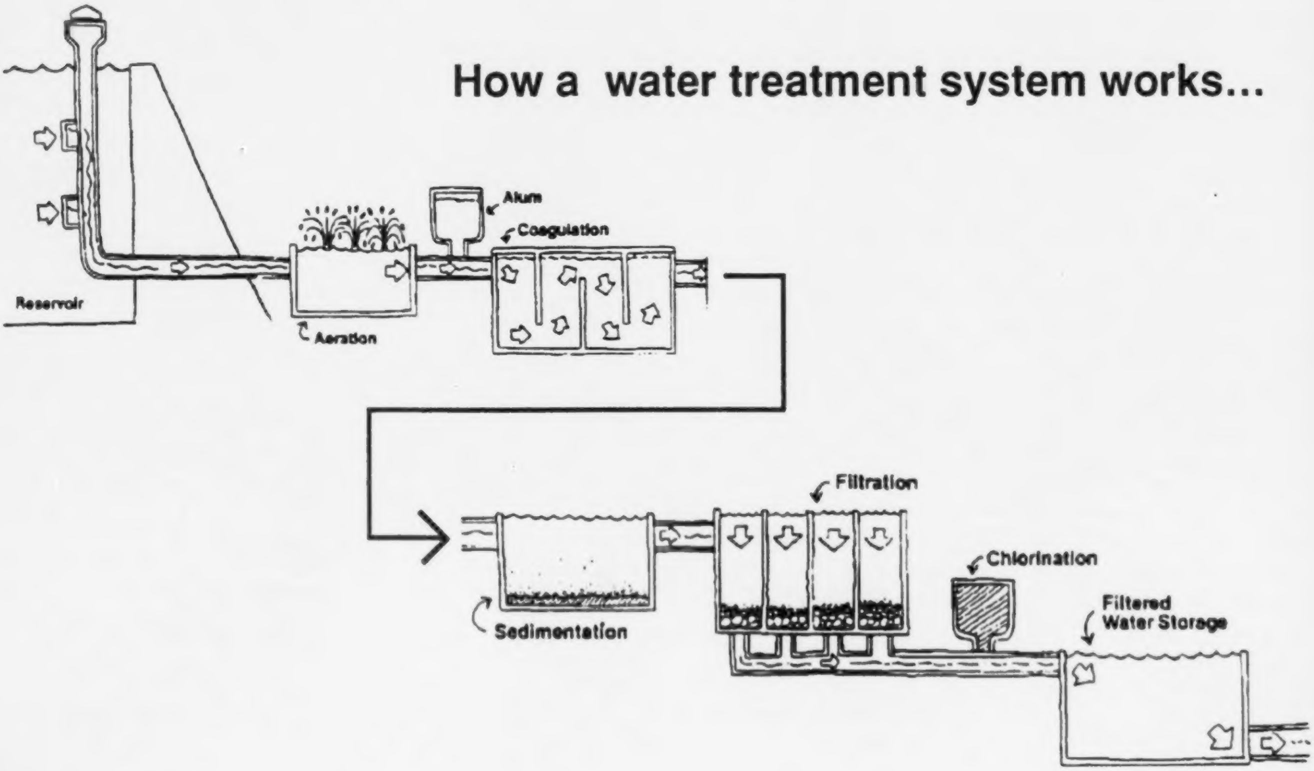
- A field trip to a local water treatment plant.
- Have the State or a certified testing laboratory conduct analyses of the students' treated and untreated water for various contaminants.

Source

Activity adapted with permission from:

Jack E. Gartrell, Jr., Jane Crowder, and Jeffrey C. Callister. *Earth: The Water Planet* (Washington, DC: The National Science Teachers Association, 1989). pp. 97-101.

How a water treatment system works...



Source: *The Official Captain Hydro Water Conservation Workbook*

Concentrations of Chemical Pollutants in Water

Background

Concentrations of chemical pollutants in water are frequently expressed in units of "parts per million" (ppm) or "parts per billion" (ppb). For example, chemical fertilizers contain nitrates, a chemical that can be dangerous to pregnant women even in quantities as small as 10 parts per million. Trichloroethylene (TCE), a common industrial solvent, is more dangerous than nitrates and when present in drinking water in quantities as small as 5 parts per million can cause a higher than normal incidence of cancer among people who drink the water regularly.

Objective

To demonstrate the concept of ppm and ppb as these units are used to explain chemical contaminant concentrations in water; to explain how chemicals may be present in very small amounts in water such that they cannot often be detected by sight, taste, or smell; though, still possibly posing as a threat to human health.

Materials

Solid coffee stirrers or tooth picks
Clean water for rinsing the dropper
Medicine dropper
Red food coloring (for "contamination")
Set of 9 clear containers
Clean water for diluting
White paper

Procedure

1) Line up the containers side-by-side and place a piece of white paper under each one. From left to right, number the containers 1 to 9.
2) Place 10 drops of food coloring into container #1 (food dye is already diluted 1:10).
3) Place one drop of food coloring into container #2.
4) Add 9 drops of clean water to container #2 and stir the solution. Rinse the dropper.
5) Use the medicine dropper to transfer 1 drop of the solution from container #2 into container #3. Add 9 drops of clean water to container #3 and stir the solution. Rinse the dropper.
6) Transfer 1 drop of the solution from container #3 to container #4. Add 9 drops of clean water to container #4 and stir the solution. Rinse the dropper.
7) Continue the same process until all 9 containers contain successively more dilute solutions.
8) Complete the discussion questions below.

Discussion

1) The food coloring in container #1 is a food coloring solution which is one part colorant per 10 parts liquid. What is the concentration for each of the successive dilutions? (Have students use the table below; each dilution decreases by a factor of 10—1/10, 1/100, 1/1000, etc.)
2) What is the concentration of the solution when the diluted solution first appeared colorless? (Usually occurs in container #6, 1/1,000,000 or 1 ppm.)
3) Do you think there is any of the colored solution present in the diluted solution even though it is colorless? Explain. (Yes. The solution is still present but has been broken down into such small particles that it cannot be seen.)
4) What would remain in the containers if all the water were removed? (Residue from the food coloring.)

Suggested Activities

1) Allow the water in the containers to evaporate and have students record their observations on what remains in the containers.
2) Discuss chemical contamination of drinking water. Use the list of maximum contaminant levels (MCLs) on the following page for some toxic or carcinogenic chemicals in drinking water (as regulated by

Container No.	1	2	3	4	5	6	7	8	9
Concentration	1/10	1/	1/	1/	1/	1/	1/	1/	1/

Source: *Water Wisdom*

the U.S. Environmental Protection Agency). These MCLs represent the maximum amount of a chemical that can occur in drinking water without the water being dangerous to human health. [Note: Some of the MCLs listed are subject to revision by EPA shortly.]

Substance	Concentration (ppb)	Substance	Concentration (ppb)
Arsenic	50	Nitrate	10,000
Barium	1,000	Selenium	10
Cadmium	10	Endrin	0.2
Mercury	2	2,4-D (herbicide)	100

Note: The above substances do not represent a complete list of regulated drinking water contaminants.

3) Explain the relationship between ppm and ppb and the conversion of these units to milligrams and micrograms per liter. For example: 1 ppm = 1000 ppb; 1 ppm = 1 mg/l; and 1 ppb = 1 ug/l.

4) Relate the previous conversions to the drinking water regulations. [MCLs are established in milligrams per liter (mg/l)]. Convert the numbers in the above chart from ppb to mg/l.

Source

Activity adapted with permission from:

Water Wisdom. (Boston, MA: Massachusetts Water Resources Authority, 1989). Exercise #16.

Contamination of an Aquifer

Background

Many communities obtain their drinking water from underground sources called **aquifers**. Water suppliers or utility officials drill wells through soil and rock into aquifers for the groundwater contained therein. Unfortunately, the groundwater can become contaminated by harmful chemicals that percolate down through soil and rock into the aquifer—and eventually into the well. Groundwater contamination by chemicals is caused mainly by industrial runoff and/or improper management of chemicals, including improper disposal of household chemicals such as lawn care products and cleaners. Such contamination can pose a significant threat to human health. The measures that must be taken by utilities to either protect or clean up contaminated aquifers are quite costly.

Objective

To illustrate how water flows through an aquifer, how groundwater can become contaminated, and how difficult it is to clean up contamination.

Materials

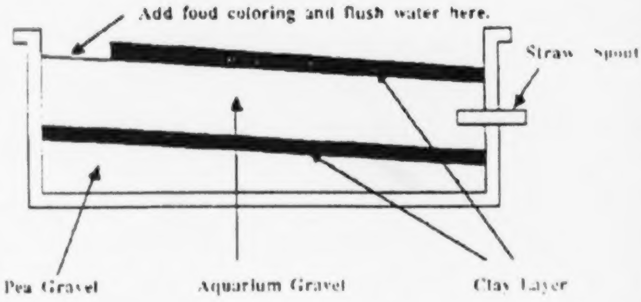
6"x8" disposable aluminum cake pans or plastic boxes
2 lbs. non-water soluble plasticine modeling clay or floral clay
3-4 lbs. white aquarium gravel
Pea gravel
Small drinking straw
Food coloring
6 oz. paper cups (no larger)
Water

Procedure

1) Set up a model aquifer as shown in the diagram below. If a disposable aluminum baking pan is used, make a small hole in one end and insert a section of a drinking straw to serve as the drain spout. Seal the hole around the straw with glue or clay. In addition, seal the clay layers of the model against the side of the container.

2) Place 10 drops of food coloring on the surface of the model near the highest end. This dye represents chemicals or others pollutants that have been spilled on the ground.

3) Slowly pour one 6-ounce cup of tap water on the aquarium gravel areas as shown in the diagram. Collect the water as it runs out of the straw. Repeat this process starting with 6 ounces of tap water and continue the flushing process until all the food coloring is washed out and the discharge water is



Source: *Water Wisdom*

clear. (Collecting the water in white paper cups or in test tubes held up against a white background will enable students to detect faint coloration.)

4) Record the number of flushings required until an output with no visible color is reached (may require up to ten flushes). [Note: 6 ounces of water in this model equals about 1 inch of rain.]

Discussion

Before the Activity

1) Where does the water go that falls on the surface of an aquifer? How about any chemicals or other pollutants that fall on the ground? (Some chemicals/pollutants are washed away by rain, some become attached to rocks and soil, and some end up in the groundwater.)

2) What things might influence the time needed to flush an aquifer clean? (Depth and volume of the water table, type of underlying rock and soil, nature and concentration of the pollutant.)

After the Activity

1) After flushing, is the water in the model aquifer completely free of food coloring? (Probably not; trace amounts may remain.)

2) Estimate how much contamination remains in the model aquifer. (Refer to previous exercise.)

3) What keeps the chemical contamination in the demonstration from reaching the lower levels of the model aquifer? (The clay layer.)

4) What are some of the problems that might result from a major chemical spill near a watershed area? (Answers will vary.)

5) What steps could be taken to avoid damage to an aquifer? (Answers will vary.)

Suggested Activities

1) Discuss the need for proper disposal of hazardous industrial wastes and harmful household chemicals, including used motor oil.

2) Simulate nitrate pollution due to fertilizer runoff. Pollute the aquifer with a small amount of soluble nitrate and perform a standard nitrate test after each successive flushing (be sure to wear safety glasses).

Source

Activity adapted with permission from:

Water Wisdom. (Boston, MA: Massachusetts Water Resources Authority, 1989). Exercise #11.

Water Use Analysis

Background

Although household and other municipal water use accounts for only about 9 percent of total water use in the United States, delivering adequate quantities of water of sufficient quality for this purpose is becoming increasingly expensive for individuals and communities. It would, therefore, be useful for individuals and communities to employ conservation measures when using water.

Objective

To demonstrate the quantities of water that an average family uses on a daily basis.

Procedure

1) Ask students to keep a diary of water use in their homes for three days. Students should make a chart similar to the one listed on the following page, adding any appropriate activities that are not listed.

2) Ask students to review the table of average water volumes required for typical activities and then answer the following questions using the data from their three-day water use diary.
    a) Estimate the total amount of water your family used in the three days. Give your answer in liters.
    b) On average, how much water did each family member use during the three days? Give your answer in liters per person per three days.
    c) On average, how much water was used per family member each day? Give your answer in liters per person per day.
    d) Compare the daily volume of water used per person in your household (Answer c) to the average daily water volume used per person in the United States (325 L per person per day). What reasons can you offer to explain any differences?

Discussion

Ask students to identify ways in which their families could reduce their water consumption.

Source

Activity adapted with permission from:
American Chemical Society. *Chemistry in the Community*. (Dubuque, IA: Kendall/Hunt Publishing Co., 1988). pp. 11, 16-17.

Average water volumes required for typical activities

Use	Volume of Water (in liters and gallons)
Tub bath	130 L (35 gal)
Shower (per min)	19 L (5 gal)
Washing machine	
Low setting	72 L (19 gal)
High setting	170 L (45 gal)
Dish washing	
By hand	40 L (10 gal)
By machine	46 L (12 gal)
Toilet flushing	11 L (3 gal)

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Data Table	Days		
	1	2	3
Number of persons in family			
Number of baths			
Number of showers			
Length of each in minutes			
Number of washing machine loads			
Low setting			
High setting			
Dish washing			
Number of times by hand			
Number of times by dishwasher			
Number of toilet flushes			
Other uses and number of each:			
Cooking			
Drinking			
Making juice and coffee			

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references

The organizations below have developed or are in the process of developing science projects related to drinking water for K-12 students. This list is not intended to be inclusive.

American Chemical Society (ACS), 1155 16th St., NW, Washington, DC 20036, (202) 872-4600 [*Chemistry in the Community*—Secondary 9-12].

American Water Works Association (AWWA), 6666 West Quincy Ave., Denver, CO 80235, (303) 794-7711 [Primary K-4; Middle/Junior 5-9].

Chemical Education for Public Understanding Program (CEPUP), Lawrence Hall of Science, University of California, Berkeley, CA 94720, (415) 642-8718 [Middle/Junior 5-8].

City of Aurora, Utilities Department, 1470 South Havana St., Aurora, CO 80012, (303) 695-7381 [Middle/Junior 5-8].

City of Seattle, 710 2nd Ave., Dexter-Horton Building, Seattle, WA 98104, (206) 684-5883 [Middle/Junior 5-8].

East Bay Municipal Utility District (EBMUD), P.O. Box 24055, Oakland, CA 94623, (415) 835-3000 [Primary K-4; Middle/Junior 5-8].

Massachusetts Water Resources Authority, Charlestown Navy Yard, 100 First Ave., Boston, MA 02129, (617) 242-6000 [Upper Primary 3-4; Middle/Junior 7-8; Secondary 9-12].

National Science Teachers Association (NSTA), 1742 Connecticut Ave., NW, Washington, DC 20009, (202) 328-5800 [Middle/Junior 5-8].

National Wildlife Federation (NWF), 1400 16th St., NW, Washington, DC 20036, (202) 797-6800 [Primary K-4; other citizen oriented material].

South Central Connecticut Regional Water Authority, 90 Sargent Dr., New Haven, CT 06511, (203) 624-6671 [Primary and Middle K-6].

suppliers

The following are some firms that provide general supplies and equipment for all areas of science teaching and also specific items for chemistry teaching.

Addison-Wesley Publishing Co., 2725 Sand Hill Rd., Menlo Park, CA 94025, [800-447-2226].

Aldrich Chemical Co., P.O. Box 355, Milwaukee, WI 53201, (414) 273-3850, [800-558-9160].

Carolina Biological Supply Co., 2700 York Rd., Burlington, NC 27215, (919) 584-0381 [800-621-4769].

Central Scientific Co., 11222 Melrose Ave., Franklin Park, IL 60131-1364, (312) 451-0150.

Connecticut Valley Biological Supply Co., Inc., 82 Valley Rd., Southampton, MA 01073, (413) 527-4030 [800-628-7748].

Edmund Scientific Co., 101 East Gloucester Pike, Barrington, NJ 08007, (609) 573-6250 [800-222-0224].

Fisher Scientific Co., Educational Materials Division, 4901 West LeMoyne St., Chicago, IL 60651, (312) 378-7770 [800-621-4769].

Flinn Scientific Inc., P.O. Box 231, 917 West Wilson St., Batavia, IL 60510, (312) 879-6900. [The Flinn Chemical Catalog also serves as a reference manual on chemical safety, storage, and disposal.]

Frey Scientific Co., 905 Hickory Lane, Mansfield, OH 44905, [800-225-FREY].

Hach Chemical Co., Box 907, Ames, IA 50010. [Test kits for environmental studies.]

Lab-Aids, Inc., 249 Trade Zone Dr., Ronkonkoma, NY 11779, (516) 737-1133.

Lab Safety Supply, 3430 Palmer Dr., P.O. Box 1368, Janesville, WI 53547-1368, (608) 754-2345. [Specialize in safety equipment and supplies.]

LaMotte Chemical Products, Box 329, Chestertown, MD 21620, (301) 778-3100. [Test kits for environmental studies.]

Nalgene Labware Division, P.O. Box 367, Rochester, NY 14602. [Specialize in transparent and translucent plastic laboratory equipment.]

NASCO, 901 Janesville Ave., Ft. Atkinson, WI 53538, (414) 563-2446 [800-558-9595].

Ohaus Scale Corp., 29 Hanover Rd., Florham Park, NJ 07932, (201) 377-9000 [800-672-7722].

Sargent-Welch Scientific Co., 7300 North Linder, Skokie, IL 60077, (312) 677-0600.

Science Kit and Boreal Laboratories, Inc., 777 East Park Dr., Tonawanda, NY 14150-6782, (716) 874-6020 [800-828-7777].

Wards Natural Science Establishment, Inc., 5100 West Henrietta Rd., P.O. Box 92912, Rochester, NY 14692, (716) 359-2502.

[The majority of suppliers listed above appeared in *Chemistry in the Community*, American Chemical Society. (Dubuque, IA: Kendall/Hunt Publishing Co., 1988).]

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